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THE EVALUATION OF THE GERMICIDAL POTENCY OF CHLORINE COMPOUNDS. I. HYPOCHLORITES

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The increasing popularity of chlorine sterilizing solutions during recent years has resulted in a growing number of commercial products being offered for sale. Not infrequently, laboratory workers are asked to report on the comparative efficiency of a series of these products from a germicidal standpoint, and the question arises as to the method of testing to be employed. Numerous workers (*2*, *6*, *8*, *10*, *11*, *12*, *13*, *14*, *17*, *19*, *20*, *21*, *22*, *26*, *27*, *28*, *29*, *30*) have reported the results of studies on chlorine sterilizing solutions, using a variety of methods. Many of these are open to the objection that they are better suited to research studies than to routine testing, as has been pointed out by Myers and Johnson (*17*). After reviewing the literature, these workers concluded that the method of the U. S. Food and Drug Administration (F.D.A. method) (*23*), using *Staphylococcus aureus* as test organism, was best adapted for practical evaluation of germicidal potencies. Using this method, results were obtained by them which were reasonably comparable to those from bottle rinsing tests in the case of hypochlorites (eleven hypochlorites were tested by the F.D.A. method and four of these were subjected to bottle rinsing tests); the single chloramine-T product, in contrast to the hypochlorites, required a greater concentration of chlorine in the bottle rinsing tests than in the test tube (F.D.A.) method against *Staph. aureus* but the reverse was true when *Eberthella typhi* was the test organism. In presenting their results, Myers and Johnson divide the eleven hypochlorites into two groups on the basis of the ratio of available chlorine to total alkalinity (as Na_2O); with the six products in the low alkalinity group (ratios 6.9 to 171.0) the "effective dilution" (that killing in ten minutes but not in five by the F.D.A. method) varied between 103 and 132 p.p.m. available chlorine, while for the five products in the high alkalinity group (ratios 0.189 to 1.69) the effective dilution ran between 285 and 301 p.p.m. Such a clear-cut grouping of these products as is indicated above appeared to be at variance with results previously reported from this laboratory (*12*), and as it became necessary about this time to conduct tests on a series of six hypochlorites and one chloramine-T product, an attempt was made to discover the reason for this lack of agreement.

EXPERIMENTAL

1. F.D.A. METHOD AND MODIFICATIONS THEREOF

A culture of *Staphylococcus aureus* (U.S.D.A. No. 209) as employed by Myers and Johnson, was kindly furnished by Dr. R. P. Myers. This

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TABLE 1.—APPROXIMATE VALUES FOR EFFECTIVE CONCENTRATIONS OF CHLORINE STERILIZING PRODUCTS AS JUDGED BY THE F.D.A. METHOD AND MODIFICATIONS THEREOF

Product	Ratio $\frac{\text{Av.Cl}}{\text{Na}_2\text{O}}$ [1]	Effective concentration (p.p.m. Av. Cl.)											
		Undiluted inoculum								Inoculum diluted 1/100			
		Broth[2]				Milk[2]				Broth[2]		Milk[2]	
B-K solution	37.1	115[1]	160,	120,	140, 140	>160,	>200,	>200	—	< 10	< 5	< 10	< 5
HTH–15	0.554	285[1]	>320,	360,	320, 320	>320,	>440,	480,	>440	< 20	< 10	< 20	< 10
Chlorosil	0.21	291[1]	>320,	340,	320 —	>320,	440,	—	400	20	20?	20?	< 20
HTH–10	—	—	>320,	400,	320 —	>320,	>440,	400	—	20?	10	20?	10
Neomoscan	—	—	>320,	420,	360 —	>320,	>440,	480	—	—	—	—	—
Diversol	0.189	289[1]	>320,	400,	400, 400	>320,	>440,	540,	520	50?	< 50	50	< 50
Wyandotte Sterilizer[3]	—	—	>320,	280?	<280 —	>320,	>440,	>440	—	100	130?	>220	>220

[1] Data by Myers and Johnson.
[2] Subculture medium.
[3] A chloramine-T product containing added alkali.

TABLE 2.—APPROXIMATE VALUES FOR EFFECTIVE CONCENTRATIONS OF DIVERSOL AND HTH–15 BY THE F.D.A. METHOD AND MODIFICATIONS THEREOF

Inoculum	Subculture medium	Effective concentration (p.p.m. Av. Cl.)															
		Diversol							HTH–15								
Undiluted	Broth	320?	<320,	320,	<320,	340,	300,	300	240?	240?	240?	240?	<240,	275,	275		
Undiluted	Milk	>600,	560,	400,	440,	340?	325,	300	480,	400,	400,	300?	240,	300,	300		
Diluted 1/100 (H_2O)	Broth	10?	< 10,	< 10,	< 5,	5,	—	—	5,	< 5,	10,	< 5,	< 5,	—	—		
Diluted 1/100 (H_2O)	Milk	10?	10,	10,	15,	10,	—	—	10,	< 5,	10,	10,	5,	—	—		

was carried on Bacto nutrient agar, and 24-hour Bacto nutrient broth cultures were employed in the testing. One cc. of culture was added to 10 cc. of test solution and subcultures were incubated at 37° C. for 4 days. In all other respects, the directions given in U.S.D.A. Circular No. 198 were followed.

Since the wide spacing of the dilutions in the work of Myers and Johnson appeared to offer a likely explanation for the quite definite grouping indicated in their results, attempts were made to work with less scattered concentrations in the hope of obtaining more accurate data concerning the "effective concentration." From the start, however, great difficulty was experienced due to the prevalence of "skips" and "misses," and various attempts to overcome this drawback were unsuccessful. Even when duplicate subculture tubes were inoculated simultaneously by means of two loops fastened together, there was by no means satisfactory agreement. The substitution of litmus milk for broth as the subculture medium raised the "effective concentration" figures by about 40%, but skips were still frequently encountered. Approximate values for the "effective concentration" of the products tested are shown in Table 1, along with the values reported by Myers and Johnson for those which they also tested. Five additional runs were made comparing HTH–15 and Diversol, the data from which appear in Table 2. From these data it would appear that even with the F.D.A. method there is a somewhat greater difference between the germicidal potency of these two products than is indicated by the values given by Myers and Johnson.

Since the latter consider bottle washing tests to be the ultimate criterion in judging sterilizing agents, several runs were made following as closely as possible the technique described by them. A small Seitz bottle washing machine, with a single rotating jet, was employed to treat the bottles with hypochlorite; 10 cc. of sterile thiosulphate solution was used

TABLE 3.—RESULTS OF BOTTLE RINSING TESTS, APRIL 11, 1933

		Bottle number					Average per bottle
		1	2	3	4	5	
	p.p.m.	Colonies per plate[1]					
Diversol	21	4900	5400	6900	1150	3900	44,500
	32	1200	5850	1530	172	—	21,880
	45	5100	372	510	5400	10400	43,560
	62	95	38	4	2600	94	5,660
	77	Spr.	0	0	1	18	50
	95	Spr.	124	2	6	2	340
HTH–15	21	2	1	19	0	3	50
	32	1	2	9	2	—	35
	39	2	3	4	3	10	44
	60	0	3	0	3	0	12
	77	0	0	1	65	0	132
	93	0	21	25	0	5	102
Control	0	27100	2100	5100	12100	6000	104,800

[1] One cc. of the 10 cc. sterile rinse plated on nutrient agar.

to rinse the bottles[2] after treatment with hypochlorite, and 1 cc. plated. Despite marked variations between bottles receiving identical treatment, the data obtained on a representative run (Table 3) indicate that HTH–15 is decidedly more effective as a bottle sterilizing rinse than is Diversol, although Myers and Johnson report effective concentrations of 38 and 29 p.p.m. respectively for these two products on bottle rinsing tests.

Discussing their reasons for selecting the F.D.A. method, the above authors mention, among other considerations, the following: "It appears to us that testing in the presence of considerable organic matter is desirable. Wherever very large numbers of bacteria are encountered, considerable organic matter is usually present. . . . . As long as the amount of organic matter is kept constant as it is in the F.D.A. method, results on different products are comparable." One obvious objection to this claim is that organic chlorine compounds, being much less influenced by the presence of organic matter, tend to appear to better advantage in such a test than in actual plant practice as the results of Myers and Johnson plainly show. Furthermore, since the seeded test solution contains at the start around one hundred million cells of the test organism per cc. there seems to be no point to introducing further large quantities of organic matter from the broth culture. Fabian, Beavens, Bryan and Jensen (*6*), studying the influence of numbers of bacteria upon the chlorine content of sodium hypochlorite solutions at 50° C., found that a suspension of one hundred million cells per cc. reduced the strength from 46 to 22.6 p.p.m. in 30 minutes, a drop far greater than is found in plant practice where properly cleaned equipment is treated with sodium hypochlorite.[3] Studies on the influence of the excessive quantities of organic matter introduced in the F.D.A. method upon the available chlorine content of Diversol at 20° C. showed a decline from 200 to 144 p.p.m. in 15 minutes; where the culture was diluted 1/100 before seeding the test solution the loss was only 8 p.p.m. Furthermore, in view of the claim of Mallmann (*15*) and Fay (*7*) that *used* hypochlorite solutions containing traces of milk are of lower potency than are *fresh* solutions showing the same concentration of available chlorine by titration, it is probable that the loss in potency in the F.D.A. method is even greater than is indicated by the titration data. In an endeavour to check upon the influence of such large amounts of organic matter, parallel tests were run using the same broth culture diluted 1/100 with distilled water and also with broth. Table 4 contains data on the undiluted broth culture, Table 5 on the broth culture diluted 1/100 with water and Table 6 on the broth culture diluted 1/100 with sterile broth. Despite irregularities it is evident that the quantity of organic matter introduced in the broth culture has an influence upon the results far in excess of that exerted by the number of organisms themselves. Since so large a proportion of the chlorine present is thus used up in reacting with the excess organic matter, one might reasonably expect that with the F.D.A. method differences in sterilizing potency between hypochlorites of varying degrees of alkalinity would be minimized. As will be shown a little further on this is actually the case.

[2] A bottle rinsed with 100 cc. of 80 p.p.m. Diversol, drained 1 minute, then rinsed with 10 cc. distilled water showed that 0.7 p.p.m. available chlorine was picked up by the rinse. To take care of this, the sterile rinse contained 0.01% of thiosulphate.

[3] This drop was practically the same as that encountered when 0.1% of ice cream mix was added to the sodium hypochlorite solution.

TABLE 4.—RESULTS OF TESTS AT 20° C. USING F.D.A. TECHNIQUE, FEB. 3. 1933 (*Staph. aureus* 67,000,000 PER CC.)

Subculture medium		Broth			Milk		
Minutes exposure		5	10	15	5	10	15
	p.p.m. Av. Cl.						
B-K	120	+	+	−	+	+	+
	140	+	−	−	+	+	+
	160	−	−	−	+	+	+
	180	−	−	−	+	+	+
	200	−	−	−	+	+	+
HTH–15	320	+	−	−	+	+	+
	360	−	−	−	+	+	−
	400	−	−	−	+	+	−
	440	+	−	−	+	+	−
	480	−	−	−	+	−	−
HTH–10	320	+	−	−	+	+	+
	360	+	−	−	+	+	−
	400	−	−	−	+	−	−
	440	−	−	−	+	−	−
	480	−	−	−	−	−	−
Chlorosil	280	+	+	−	+	+	+
	320	+	−	−	+	+	+
	360	+	+	−	+	+	+
	400	−	−	−	+	−	−
	440	+	−	−	+	+	−
Neomoscan	320	+	+	−	+	+	+
	360	+	−	+	+	+	+
	400	+	−	−	+	+	+
	440	−	−	−	+	+	−
	480	−	−	−	−	−	−
Diversol[1]	400	++	−−	−−	++	++	++
	440	+−	+−	−−	++	++	++
	480	−−	−−	−−	++	++	−+
	520	−+	+−	−−	++	++	+−
	560	−+	−−	−−	−+	−+	−−
Wyandotte Sterilizer	280	−	−	−	+	+	+
	320	−	−	−	+	+	+
	360	−	−	−	+	+	+
	400	−	−	−	+	+	+
	440	−	−	−	+	+	+

[1] The data here represent two sets of determinations made on this product during a single run.

TABLE 5.—RESULTS OF TESTS AT 20° C. USING F.D.A. TECHNIQUE, FEB. 3, 1933. (*Staph. aureus* 1,000,000 PER CC. . ORIGINAL CULTURE DILUTED 1:100 WITH H_2O

Subculture medium		Broth			Milk		
Minutes exposure		5	10	15	5	10	15
	p.p.m. Av. Cl.						
B–K	5	−	−	−	−	+	−
	10	−	−	−	−	−	−
	15	−	−	−	−	−	−
	20	−	−	−	−	−	−
	25	−	−	−	−	−	−
HTH–15	10	−	−	−	−	−	−
	20	−	−	−	−	−	−
	30	−	−	−	−	−	−
	40	−	−	−	−	−	−
	50	−	−	−	−	−	−
HTH–10	10	−	−	+	+	−	−
	20	−	−	−	−	−	−
	30	−	−	−	−	−	−
	40	−	−	−	−	+	−
	50	−	−	−	−	−	−
Chlorosil	20	+	−	−	−	−	−
	30	−	−	−	−	−	−
	40	−	−	−	−	−	−
	50	−	−	−	−	−	−
	60	−	−	−	−	−	−
Diversol	50	−	−	−	−	−	−
	65	−	−	−	−	−	−
	80	−	−	−	−	+	−
	95	−	−	−	−	−	−
	110	−	−	−	−	−	−
Wyandotte Sterilizer	100	+	+	−	+	+	+
	130	+	−	−	+	+	+
	160	+	+	+	+	+	+
	190	+	−	−	+	+	+
	220	−	−	−	+	+	+

TABLE 6.—RESULTS OF TESTS AT 20° C. USING F.D.A. TECHNIQUE, FEB. 3, 1933. (*Staph. aureus* 1,000,000 PER CC.—ORIGINAL CULTURE DILUTED 1 : 100 WITH BROTH)

Subculture medium		Broth			Milk		
Minutes exposure		5	10	15	5	10	15
	p.p.m. Av. Cl.						
HTH–15	320	−	+	+	−	+	+
	360	−	−	−	−	−	−
	400	−	−	−	+	−	−
	440	−	−	−	−	−	−
	480	−	−	−	−	−	−
Diversol	400	+	−	−	+	+	+
	440	−	−	−	−	−	−
	480	−	+	+	−	−	+
	520	+	−	−	+	+	+
	560	+	−	−	+	+	+

2. LITMUS MILK TUBE METHOD

In order to avoid the excess of organic matter which the F.D.A. method employs, the test organism was next grown on agar slants, the growth suspended in sterile tap water and standardized so that the seeded test solution would contain ten million cells per cc. at the start. Subcultures were made in litmus milk tubes using first of all the double loop method. Later, one cubic centimeter portions of the seeded solution were subcultured in litmus milk in the hope of obtaining more regular results. Using this method, studies were then carried on in an endeavour to explain the findings reported by Fabian et al (*6*) the results of which are reported in detail in a separate paper (*13*). These workers stated that "the addition of alkalies to sodium hypochlorite increases its germicidal power," a conclusion at variance with that reached by a number of workers (*10, 12, 14, 20*). This apparent contradiction was found to be due to the susceptibility of *Escherichia coli* (Fabian's test organism) to alkalies at 50° C., the killing being attributable to pH and temperature and *not to any increase in the germicidal potency of the hypochlorite* due to added alkali. At 20° C., added alkali depresses germicidal speed for this organism, and the same is true for *Staphylococcus aureus* at both temperatures.

3. BURRI SLANT METHOD

With the litmus milk tube method, "skips" and "misses" were still far too frequent for the method to be considered satisfactory. At this point Dr. R. P. Myers, who had been kept informed concerning our findings, agreed that the F.D.A. method was open to serious objection and that the use of a suspension containing less organic matter (such as was employed in the litmus milk tube method) would be more satisfactory. He also suggested (*18*) the adoption of the Burri slant method (*1*) for subculturing, since results by such a method would be roughly quantitative and errors resulting from the occasional carrying over of a resistant cell would be largely eliminated. The Burri slant method was therefore tested out along with the milk tube method on a series of eight sodium hypochlorite products and found to give a more definite end-point, with fewer "skips" and "misses" (Table 7). Later, when the modification of filtering the suspension of *Staph. aureus* through Whatman No. 41 paper before standardizing was adopted, few further irregularities were encountered, indicating that clumps of organisms which had not been broken up in shaking were the probable cause of "skips." The apparently greater resistance of the test organism with the milk tube method is believed to be due to the much heavier inoculum employed in subculturing—approximately three thousand times as great as with the Burri slant method.

4. INDICATOR METHOD FOR pH DETERMINATIONS

For some time the writer had been seeking a simple chemical test which would give information as to the germicidal potency of sodium hypochlorite solutions, and thus avoid the necessity for the more complicated bacteriological testing. Since all available data indicated the marked influence of alkalinity upon germicidal speed, it seemed that pH determinations might be used to judge of the relative potency of hypochlorite products. In order to study the correlation between germicidal potency and pH, it became necessary to make fairly accurate pH determinations.

TABLE 7.—COMPARATIVE RESULTS ON EIGHT SODIUM HYPOCHLORITE PRODUCTS BY THE BURRI SLANT AND MILK TUBE METHODS AT 20° C., SEPT. 28, 1933

Concentration of Av. Cl.	25 p.p.m.								25 p.p.m.								50 p.p.m.							
Method of sub-culturing	Burri slant								Milk tube[1]								Milk tube[1]							
Period of exposure (minutes)	¼	½	1	2	5	10	20	30	¼	½	1	2	5	10	20	30	¼	½	1	2	5	10	20	30
Sallex	0	0	0	0	0				−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
	0	0	0	0	0				+	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
B–K	0	0	0	0	0				+	−	−	−	−	−	−	−	+	−	−	−	−	−	−	−
	0	0	0	0	0				+	−	−	−	−	−	−	−	+	−	−	−	−	−	−	−
HTH	0	0	0	0	0				−	−	−	−	−	−	−	−	−	+	−	−	−	−	−	−
	0	0	0	0	0				+	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
HTH–15	+++	56	0	0	0				+	+	+	+	−	−	−	−	+	+	+	+	+	−	?	−
	+++	90	0	0	0				+	+	+	+	−	−	+	−	+	+	+	+	−	+	−	?
HTH–10	+++	+++	0	0	+++	0	0	0	+	+	+	+	+	+	−	−	+	+	+	+	−	+	−	−
	+++	++	0	0	0	0	0	0	+	+	+	+	+	−	−	−	+	+	+	+	+	−	?	−
Chlorosil	+++	107	0	0	0	0	0	0	+	+	+	+	+	+	−	−	+	+	+	+	?	−	+	+
	+++	12	0	0	0	0	0	0	+	+	+	+	+	+	−	−	+	+	−	+	+	−	−	−
Diversol (old)	++++	++++	++++	+++	0	0	0	0	+	+	+	+	+	+	+	+	+	+	+	+	+	?	?	?
	++++	++++	++++	++	0	0	0	0	+	+	+	+	+	+	+	−	+	+	+	+	+	−	−	?
Diversol (new)	++++	++++	++++	1	0	0	0	0	+	+	+	+	+	?	+	?	+	+	+	+	?	+	?	?
	++++	++++	++++	11	0	0	0	0	+	+	+	+	?	+	−	?	+	+	+	+	+	+	?	+

[1] One cc. of seeded NaOCl solution pipetted into 10 cc. sterile litmus milk.
N.B.—With the milk tubes, + = growth of test organism, − = no growth after 4 days at 37°.
With the Burri slants, the density of growth is indicated by the number of plus signs, except where the number of colonies was countable.

Earlier attempts at colorimetric determinations not having proven satisfactory, efforts were made to obtain data electrometrically.[4] However, satisfactory results could not be obtained with either hydrogen or quinhydrone electrodes, although both thiosulphate and peroxide were used to remove the available chlorine. Recalling that Cullen and Austin (*3*) mention the employment of powdered phenolphthalein as a rough end-point indicator of the degree of alkalinity of Dakin's solution (5000 ± p.p.m.) this was tried out on the 8 products shown in Table 7, and was *found to give gradations in colour in 50 and 100 p.p.m. solutions which closely paralleled their germicidal potency.* A 1% alcoholic solution of the same indicator will also furnish an indication of the alkalinity of the hypochlorite since the time required for decolorization increases with increasing alkalinity. Where a number of solutions are being compared, however, the powder method is more convenient, since the colour remains practically unchanged for several hours, and the solutions are more readily arranged in order of increasing alkalinity. Phenolphthalein is universally employed in dairy and other food plants as an indicator in titration, hence is readily available.

A convenient method of conducting the test is to weigh out accurately 10 mgm. lots of powdered phenolphthalein and place in each of a series of specially cleaned test tubes. The products to be tested are diluted to the concentration of chlorine desired for plant use (usually 50 or 100 p.p.m.) and 10 cc. quantities pipetted into correspondingly marked tubes. When all tubes have been so prepared, they are shaken vigorously four or five times and returned to the rack. After a minute or two the full colour has developed, and tubes may be arranged in order of increasing colour. The least alkaline products remain colourless or show only a faint magenta tint. As the alkalinity increases, the magenta colour deepens. With still higher alkalinity a reddish shade appears until with the most alkaline products (pH ca 11.5) the solution appears a deep ruby red, which Cullen and Austin attribute to the formation of red alkaline phenolphthalate. It should be noted that the degree of colour developed is considerably influenced by the amount of indicator powder added, hence care must be taken to add equal quantities to every tube in the series.

It was at first thought to be necessary to remove the available chlorine by adding the required amount of sodium thiosulphate solution, but it was later found that this step could be eliminated. In the test with the alcoholic solution of the indicator, if the available chlorine is removed, all solutions (except those of pH <9.6) assume the full magenta colour of the indicator and no differentiation is possible.

5. INDICATOR METHOD CHECKED AGAINST BURRI METHOD

In order to give the powdered phenolphthalein test a more thorough trial, twenty commercial sodium hypochlorite products were obtained; their relative germicidal potency was tested out by the Burri Slant method and compared with the order of alkalinity by the indicator test. In the first tests at 10 p.p.m. no differences could be detected between the nine least alkaline products, so further tests were conducted at reduced chlorine

[4] Thanks are due to Messrs. C. H. Robinson and J. T. Jansen of the Division of Chemistry, Central Experimental Farm, for assistance in this phase of the work.

concentrations. Data from one such run at 2 p.p.m. in which determinations were made in duplicate are presented in Table 8. In this table the

TABLE 8.—GERMICIDAL POTENCY OF NINETEEN SODIUM HYPOCHLORITE SOLUTIONS AT 2 P.P.M. AV. CL. AS MEASURED BY THE BURRI SLANT TECHNIQUE AT 20° C., JAN. 4, 1934

	Ranking in alkalinity by indicator test at *100* p.p.m.	Period of exposure (minutes)							Ranking in alkalinity by indicator test at *2* p.p.m.
		¼	½	1	2	5	10	20	
B–K solution	1	0 0	0 0	0 0	0 0				1
Merclor	1	0 0	0 0	0 0	0 0				1
HTH	2	0 0	0 0	0 0	0 0				1
Sallex	3	0 0	0 0	0 0	0 0				1
Germo Kil	4	0 0	0 0	0 0	0 0				1
B–K Powder	4	0 0	0 0	0 0	0 0				1
Washine	4	0 0	0 0	0 0	0 0				1
Dalglish	4	0 0	0 0	0 0	0 0				1
Perchloron	4	0 0	0 0	0 0	0 0				1
Jerdis	5	0 0	0 0	0 0	0 0				1
HTH–10 B	5	+ 83	0 0	0 0	0 0	0 0			2
Chlorosil	6	+ +	+ +	+ +	8 18	0 0			4
HTH–15	6	+ +	0 0	0 0	0 0	0 0			2
HTH–10 A	6	+ +	+ +	4 0	0 0	0 0			3
Pure-A-Fac	7	0 0	0 0	0 0	0 0	0 0			2
Antiformin	7	0 0	0 0	0 0	0 0	0 0			1
Neomoscan	8	+ +	+ +	+ +	+ +	0 5	0 0	0 0	6
Diversol (new)	8	+ +	+ +	+ +	0 0	0 0	0 0	0 0	5
Diversol (old)	8	+ +	+ +	+ +	+ +	0 0	0 0	0 0	6

+ = too numerous to count.

products are arranged in approximately the order of increasing alkalinity *as determined by the indicator test at 100 p.p.m.*[5] to exhibit the correlation between alkalinity and germicidal speed. While there is no question as to the general trend, it is obvious that certain products, notably Pure-A-Fac and Antiformin, show greater germicidal potency than would be expected from the alkalinity rating. These anomalous results suggested that differences in buffer capacity of the solutions might be responsible, since the alkalinity was being determined on 100 p.p.m. while the germicidal tests were on 2 p.p.m. Accordingly, alkalinity tests were conducted on the 2 p.p.m. solutions, and the approximate ranking as shown in the last column of Table 8 supports the above hypothesis. More exact data were secured some weeks later by means of the glass electrode, and the pH values of these solutions at 100 and at 2 p.p.m. are given in Table 9. From these data it is evident that a method of germicidal testing which makes use of a very low concentration of available chlorine[6] may, in the case of poorly buffered products such as Pure-A-Fac and Antiformin, indicate a comparative efficiency much greater than will be found where these products are employed at concentrations of 50 p.p.m. or higher.

[5] This value was selected when developing the test as being the minimum strength generally recommended for rinsing or flushing out dairy utensils and equipment. At concentrations as low as 2 p.p.m. it is more difficult to obtain colour differences between solutions of mild alkalinity.

[6] Such a method also introduces difficulties due to the rapidity with which the available chlorine is dissipated even at room temperature.

TABLE 9.—INFLUENCE OF DILUTION UPON pH VALUES OF VARIOUS SODIUM HYPOCHLORITE SOLUTIONS, MARCH 16, 1934

Product	pH at 100 p.p.m. Av. Cl.	pH at 2 p.p.m. Av. Cl.	Drop in pH
B–K Solution	9.2	6.6	2.6
Merclor	9.5	6.2	3.3
Germo-Kil	9.6	6.3	3.3
Sallex	9.7	6.3	3.4
HTH	9.9	6.5	3.4
B–K Powder	10.2	6.7	3.5
Perchloron	10.2	6.3	3.9
Dalglish	10.3	6.8	3.5
Washine	10.4	6.8	3.6
HTH–10 B	10.5	9.1	1.4
Jerdis	10 7	6.9	3.8
Klor-Rin	11.0	9.1	1.9
Chlorosil	11.0	9.6	1.4
HTH–15	11.2	8.9	2.3
HTH–10 A	11.2	9.4	1.8
Antiformin	11.4	8.4	3.0
Pure-A-Fac	11.6	8.6	3.0
Diversol (New)	11.6	9.6	2.0
Neomoscan	11.7	9.9	1.8
Diversol (Old)	11.9	10.0	1.9

6. PLATING METHOD

Since the amount of seeded solution carried over to the Burri slant is so small (ca 0.0003 cc.) it was hoped that the subculturing of a larger amount would enable the detection of differences in germicidal speed among the more active hypochlorites. Accordingly, the technique for the Burri method was modified to allow the pipetting of 1 cc. portions of seeded test solution into sterile petri dishes after definite periods of exposure, nutrient agar being poured in immediately to stop the action of the chlorine. The data appearing in Table 10 however indicate that with the more active hypochlorites no difference in speed can be detected by this method

TABLE 10.—GERMICIDAL POTENCY OF TWELVE HYPOCHLORITE SOLUTIONS AT 2 P.P.M. AV. CL. AS MEASURED BY THE PLATING METHOD AT 20° C., JAN. 31, 1934

—	Period of exposure (min.)							
	¼		½		1		2	
Germo Kil	420	242	121	102	62	45	24	18
Sallex	233	Spr.	133	141	60	70	43	39
B–K solution	244	296	118	139	72	62	23	33
B–K Powder	244	280	128	146	56	58	29	39
HTH	342	284	142	197	100	80	66	45
Perchloron	290	314	126	156	76	68	30	33
Dalglish	328	448	165	207	76	76	49	45
Jerdis	310	290	128	200	71	80	Spr.	40
Merclor	298	312	141	150	56	79	33	36
Washine	246	490	147	206	50	69	40	43
Antiformin	1200	1086	200	248	70	54	19	161
HTH–15	+++[1]	+++	+	+	133	196	23	62

[1] Plus signs indicate density of colonies where plates were too crowded for counting.

although the slightly slower killing by Antiformin did not show up under the Burri technique. The lag in killing with Antiformin and HTH–15 is evidently associated with higher alkalinity as the pH values obtained subsequently with the glass electrode indicate (Table 9).

It is interesting to observe that after two minutes exposure there is little difference between the two more alkaline solutions and the remaining ten. Apparently a small number of resistant cells are able to survive even the more active hypochlorites for this length of time. With the Burri technique the amount subcultured is so small that one of these resistant cells is not often included. Furthermore, the initiation of growth by a single cell is generally recognized as being much more difficult, so the absence of growth on the Burri slants is not surprising.

The results recorded in Table 10 indicate that the more active hypochlorites at 2 p.p.m. destroyed approximately 99.997% of the test organisms within fifteen seconds, and that no significant differences in speed could be detected. Since the plating method is more expensive than the Burri method as well as being open to the objections recorded in the last paragraph of Section 5, there seemed to be no advantage in employing it more extensively for routine testing.

7. GLASS SLIDE METHOD

Since all of the biological testing methods so far described are open to serious objection, an attempt was made at this point to develop one which would prove more satisfactory. In the sterilization of dairy equipment and utensils the problem is to destroy or remove organisms present on a surface in a thin film containing more or less organic matter (milk solids). This is obviously a more difficult task than the destruction of the test organisms when freely suspended in the sterilizing solutions as in the usual methods of disinfectant testing. Furthermore, the greater detergent properties of the more alkaline hypochlorites might be expected to compensate to some extent for the depressive action of the alkalinity upon germicidal speed, a feature which the usual methods do not take into account. Finally, it was considered desirable that the method be readily applicable to solutions at concentrations similar to those commonly employed in plant practice, in order that anomalies such as were encountered with the Burri slant method might be avoided.

The first trials were made with the test organisms present in a film of gelatin covering the lower half of a metal strip, which was then immersed in the hypochlorite solution for the required period, transferred to a sterile petri dish and nutrient agar poured over the strip to stop the action of the chlorine on the surviving bacteria. Gentle agitation of the strip while in the hypochlorite was found to reduce materially the number of organisms remaining on the slide. Since in plant practice the flushing or rinsing solution is moving over the surface to be sterilized, the agitation of the metal strips was adopted as a feature of this test. It was found difficult to get the film of gelatin to adhere uniformly to the surface of the metal strip, so glass microscopic slides were substituted. These, where carefully cleaned, gave no trouble in this respect, and in addition had the advantage of transparency. After several trials, skim milk, diluted to one-tenth, was substituted for gelatin as being more representative of the organic matter encountered on dairy equipment and utensils.

In the tests employing this method, a suspension of *Staph. aureus* No. 209 was prepared from a 24-hour growth on Bacto nutrient agar, filtered through a Whatman No. 41 paper, and standardized to contain approximately 250,000,000 cells per cc. One cubic centimeter was then mixed with 60 cc. of 1/10 dilution of sterile skim milk in a jelly jar with metal cover. (This quantity is sufficient to half immerse a 1″ × 3″ microscopic slide). A slide was dipped into the milk suspension, removed, the excess liquid allowed to drain off and the slide placed on end in a specially constructed draining pail, where several layers of filter paper on the perforated false bottom promoted further drainage of the excess of milk suspension. Sufficient slides to make the necessary tests on a given solution were prepared in succession and placed in the draining pail. After the last slide was treated the first was removed, immersed in 100 cc. of the hypochlorite solution in a sterile 100 cc. beaker and gently agitated during the exposure period. At the end of this period, the slide was quickly transferred to a petri dish and the plate poured immediately with nutrient agar. After incubation at 37° C. for forty-eight hours the number of colonies was recorded. Control slides were plated direct from the draining can and an estimate made of the number of colonies present. (A later modification consisted of preparing a milk suspension with 1 cc. of a 1/100 dilution of the standardized suspension of *Staph. aureus*. Control plates poured from slides dipped into this suspension were much more easily counted. The average number was then multiplied by 100 to compensate for the dilution of the suspension). This number was then used to calculate the number of colonies allowable at the end-point, which was usually the shortest period in which 99.75% of the organisms had been killed or removed. All equipment and supplies used in the test were carefully sterilized before use and care was taken to avoid contamination during the testing. All tests were conducted at 20° C.; at this temperature the number of organisms in the milk suspension increased gradually (approximately 50% in two hours) but this had no detectable influence upon the results. (Jensen and Jensen (*9*) in their recent description of a technique in which a loopful of a suspension of *Staph. aureus* is dried upon a cover slip and then immersed in the disinfectant, have varied the number of organisms in their suspension eight-fold without detecting any difference in results). On the other hand, an attempt to prevent growth by holding the milk suspension in ice water resulted in a tremendous increase in resistance within a similar period.

8. TESTS ON SODIUM HYPOCHLORITE PRODUCTS USING GLASS SLIDE METHOD

After a number of preliminary tests, the glass slide method was tested out upon a series of 13 hypochlorites of varying alkalinity at a concentration of 100 p.p.m. Av. Cl. The results of one such run are presented in Table 11 where the end point has been calculated[7] as the destruction of 99.75% of the estimated number present on the control slides. In this particular experiment the counts appearing in the left-hand column under each exposure period were obtained in one run, and those in the right-hand column in a later run on the same day using a fresh suspension of the test organism. In one run the solutions were tested in the order shown in the table, and in the other, in the reverse order. The product Klor-Rin

[7] The average count of the two plates was taken in calculating the end point for each product.

TABLE 11.—GERMICIDAL POTENCY OF SODIUM HYPOCHLORITE SOLUTIONS AT 100 P.P.M. AV. CL. AS MEASURED BY GLASS SLIDE TECHNIQUE, AT 20° C., MARCH 1, 1934

Product	pH	Period of exposure (min.)											
		⅛		¼		½		1		2		5	
B–K solution	8.96	3	**1**	0	0	0	0						
HTH	9.8	**0**	**0**	0	0	0	0						
Jerdis	10.45	**74**	**11**	34	0	63	0						
HTH–10 B	10.5	330	+	**2**	**3**	1	0						
Klor-Rin	10 75			+	+	**37**	**4**	0	5	2	0		
Klor-Rin	10.75			608	247	**8**	**1**	3	0	2	0		
Chlorosil	10.92			+	+	**2**	**1**	0	3				
HTH–10 A	11.0			+	+	87	315	**0**	**0**	0	0		
HTH–15	11.2			+	+	522	311	**7**	**0**	0	1		
Antiformin	11.35			+	+	205	660	**5**	**14**	1	0		
Pure-A-Fac	11.35			+	+	800	363	**119**	**1**	0	0		
Neomoscan	11.52			+	+	226	804	**24**	**110**	0	3	0	0
Diversol (new)	11.52			+	+	119	800	**11**	**42**	0	0		
Diversol (old)	11.85			295	+	199	186	**60**	**14**	1	1	4	0

+ = >500 colonies.
Control slides estimated at 35,000.
∴ a count of <88 = 99.75 per cent reduction.

was tested at the beginning and end of each run, in order to check on possible variations in the resistance of the test organism in the diluted skim milk during the approximately two hour period of each run. As will be observed from Table 11, no significant change in resistance is evident, and this point has been substantiated by the results of several other tests.

Throughout these studies it is evident that germicidal speed is retarded with increasing pH. The data recorded in Table 11 however suggest that with the glass slide technique there may be some factor operating at pH >11.0 whereby the influence of further increase in alkalinity is at least partially compensated for. It seemed probable that this factor might be detergent action, since Diversol (old) solution at 100 p.p.m. chlorine contains approximately 0.33% of tri-sodium phosphate. Tests were made upon several occasions in which sterile solutions of tri-sodium phosphate and sodium carbonate of appropriate concentrations were compared with distilled water in their ability to remove the test organisms and their accompanying milk film at 20° C. but no significant difference was observed. Further tests using 100 p.p.m. solutions of old Diversol, Chlorosil and HTH to which sufficient sterile sodium thiosulphate had been added to react with the available chlorine again showed no advantage over distilled water. Since no superior detergent action could be shown even with the most alkaline product, a series of eleven hypochlorites was tested out with shorter intervals between the periods of exposure, in hopes of detecting differences which might have been missed in the work reported in Table 11.

The results from this series are given in Table 12, the products being arranged in order of increasing pH as determined with the glass electrode on 100 p.p.m. solutions. Here, with the exposure periods more closely spaced, it will be observed that there is still some slowing down in germicidal speed above pH 11.0. Along with the eleven hypochlorite products are shown results from two other chlorine disinfectants. The first of these,

TABLE 12.—GERMICIDAL POTENCY OF CHLORINE SOLUTIONS AT 100 P.P.M. AV. CL. AS MEASURED BY GLASS SLIDE TECHNIQUE AT 20° C., MAY 3, 1934

	pH	Period of exposure (seconds)																							
		1	5		10		15		20		30		40		50		60		75		90		120		300
B-K	9.2	**14**	4	0	0	0	0																		
Merclor	9.8	**1**	0	1	0	1	0																		
HTH	10.1	**2**	1	0	0	1	0																		
HTH–10 B	10.6				**9**		2	1	0	0	7	3	0	1	0										
Chlorosil	10.9								215		**53**	**10**	7	0	1	0	2	0	0						
HTH–15	11.4										+		+	+	412	290	**38**	**37**	0	0					
Antiformin	11.52										+		+		+	+	142	36	**1**	**4**	1		0		
Diversol (new)	11.56										+		+		+		+	+	**31**		6		0		
Pure-A-Fac	11.65										+		+		+	+	+	+	**72**	**9**	2		1		
Neomoscan	11.7												+		+		+	+	270	121	**8**	**4**	1	0	
Diversol (old)	11.95												+		+		+	+	+	+	**41**	**18**	0	0	
HC	10.5								+		+	+	+	+	+	+	+	+	+	+					
Azochloramid (sat'd. aqueous)	6.0						+	+			+	+			+	+	+	+			+	+	+	+	. 460

HC, was assumed to be a hypochlorite (being far more alkaline than any chloramine-T compound encountered so far), and exposure periods were chosen accordingly. However, subsequent testing with the O-tolidene method has shown the very slow development of colour characteristic of the chloramine-T compounds. Azochloramid, a recently developed product (*24*) said to be extremely stable in the presence of organic matter, was tested as a saturated aqueous solution, but appears to be too slow acting for the sterilization of metal surfaces.

In view of the fact that hypochlorite solutions showing such tremendous differences in sterilizing speed are being employed in dairy sanitation, it appeared to be of interest to determine how much stronger solutions of a few of the more alkaline products would need to be in order to kill as rapidly as a product such as HTH. Data obtained with the glass slide technique are presented in Table 13, and indicate that where the

TABLE 13.—EQUIVALENT CONCENTRATIONS OF FOUR SODIUM HYPOCHLORITE PRODUCTS AS JUDGED BY GLASS SLIDE TECHNIQUE AT 20° C.

	p.p.m. Av. Cl.	Period of exposure in seconds				
		5	10	15	20	40
HTH *(a)*	10	**26** **5**	1 4	6	1	
(b)	10	**81** **43**	5 100		0	1
HTH-10 B *(b)*	100	++	252		**3** **0**	1
	150	++ ++	**5** **1**		0	0
	200	**0** **0**	0 0		0	0
HTH-15 *(a)*	200	++	+ 430	**12** **8**	11 10	
	300	**42**	8 11	5 3	0	
	400	**60** **52**	1 3	0 1	0	
	500	**12** **2**	1 2	0 0	0	
Diversol (old) *(b)*	100	+	363		233 12	**24** **3**
	200	Spr.	109 19		**5** **71**	0
	300	**55** **5**	25 48		0 0	0
	400	Spr. **64**	6 2		0	0

N.B.—*(a)* Test of March 27, 1934.
(b) Test of April 6, 1934.
The counts in black type mark the shortest exposure period where the average of two plates indicates 99.75% destruction. Control plates estimated at 30,000.

exposure period must be brief, much stronger solutions of the more alkaline hypochlorites are necessary to obtain the same degree of destruction.

9. THE EFFECT OF ADDING SODIUM THIOSULPHATE TO NUTRIENT AGAR

In the studies reported in this and previous papers it has been assumed that the organic matter in nutrient agar would react with and stop further action of the chlorine in the portion of the test solution transferred for subculturing. However, at this stage (May, 1934) the correctness of this assumption was tested by making parallel sets of determinations with the glass slide method on representative products, pouring one set with nutrient agar in the usual manner and the other with nutrient agar to which 0.1% sodium thiosulphate had been added just before pouring the plates. The

data obtained (Table 14) indicate that some further killing or inhibition of growth does take place after the plate has been poured with nutrient

TABLE 14.—EFFECT OF ADDING SODIUM THIOSULPHATE TO NUTRIENT AGAR UPON COUNTS OBTAINED WITH THE GLASS SLIDE METHOD ON HYPOCHLORITE SOLUTIONS OF 100 P.P.M. AV. CL. AT 20° C., MAY 17, 1934

	Period of exposure (seconds)											
	1	5	10	20	30	40	50	60	75	90	120	150
HTH *(a)*	**10**	1	0									
	71	1	1									
HTH *(b)*	83	**0**	0									
	+	**9**	0									
HTH–15 *(a)*					+	667	**43**	1	10			
					+	195[1]	**38**	8	1			
HTH–15 *(b)*					+	+	363	141	**10**	3		
					+	84	472	158	**2**	2		
HTH–15 *(c)*					+	+	383	99	**0**			
					+	+	?	43	**1**			
Diversol (old) *(a)*							380[1]	481	238	154	**28**	
							339[1]	155[1]	100[1]	45	**20**	
Diversol (old) *(b)*								+	+	+	213	**5**
								+	+	+	97	**1**

(a) = nutrient agar;
(b) = nutrient agar + 0.1% thio, fresh;
(c) = same as *(b)*, but several weeks old, and had been autoclaved 4-5 times.
\+ = >500 colonies;
[1] = count lowered by spreaders.
<56 per slide = 99.75 per cent reduction.

agar. However, there is no reason to believe that the ranking in order of relative potency of a series of hypochlorite products would be disturbed by the employment of thiosulphate. Nevertheless for future studies it was decided to dip the glass slides in a sterile 1% solution of thiosulphate immediately after removal from the hypochlorite solution and thus make certain that the action of the chlorine is checked instantaneously.

10. THE EFFECT OF DILUTION UPON THE GERMICIDAL POTENCY OF HYPOCHLORITE SOLUTIONS

In all published data which the writer has seen,[8] increasing dilution of the hypochlorite solution has resulted in a decline in germicidal speed. However, the data obtained with the Burri slant method between September, 1933, and January, 1934, indicated no significant difference between the first tests using 25 p.p.m. and later ones using 10 and 2 p.p.m. available chlorine. At the time this was attributed to a decline in the resistance of the test organism, although this point was not investigated. However, glass electrode studies made some weeks later on the effect of dilution upon the pH of a number of hypochlorites showed that the curve came down very sharply in this region (the distilled water, autoclaved in

[8] An exception occurs in the paper of Ram Ayyer (*21*) where a concentration of 20 p.p.m. was more effective than 100 or 200 p.p.m. in the destruction of spores of *B. subtilis*. The explanation offered, that nascent chlorine is liberated slowly on dilution, scarcely appears to be adequate.

2 liter Pyrex flasks, used in dilution usually had a pH value of between 5.3 and 6.0) suggesting that this marked change in pH might exert some influence.

In order to determine more definitely just what effect dilution had upon germicidal potency, HTH–15 solution (selected as being intermediate in alkalinity and buffer capacity) was tested out with *(a)* the plating method and *(b)* the glass slide method on dilutions made up to contain 25, 10, 2 and 1 p.p.m. as prepared. In order to control more accurately the period of exposure to the test solution in the plating method, 1 cc. of sterile 1% sodium thiosulphate solution was placed in each petri dish to check further action of the chlorine when 1 cc. of seeded test solution was pipetted into the petri dish. With the glass slide method, the treated slides were dipped into sterile 1% thiosulphate solution as described in Section 9. From the data in Table 15 it will be observed that there is no great difference between 25 and 10 p.p.m. but that 2 p.p.m. is distinctly more active than 10 p.p.m. The results with 1 p.p.m. are rather peculiar. With the plating method it would seem that the addition of over nine million cells per cc. reduced the amount of available chlorine to the point where it was insufficient to cause any significant destruction, since plates poured after two minutes showed as heavy growth as those poured after thirty seconds. With the glass slide method, 1 p.p.m. appears to be almost as effective as 2 p.p.m. on the first few slides but as the organic matter content of the test solution increases (due to the washing off of the milk film from the slides), its potency declines, and thus the later slides show more surviving organisms despite the longer exposure period.

The explanation of these anomalous results is believed to lie in the effect of pH upon the proportion of the total "available chlorine" existing in the form of hypochlorous acid, it being generally conceded that the latter is the germicidally active component. Determinations were therefore made of the pH values of HTH–15 solution at concentrations between 25 and 1 p.p.m. available chlorine. From these data the concentration of hypochlorous acid was calculated for each point by the Henderson-Hasselbalch equation, $pH = pKa + \log (salt)/(acid)$, employing Sand's (*24*) value (recently confirmed by glass electrode electrometric titration by Davidson (*4*)) of 3.7×10^{-8} for Ka. Both sets of data are presented graphically in Figure 1, where we observe that the minimum concentration of hypochlorous acid occurs with this particular product in the neighbourhood of 20 p.p.m., rising sharply as the pH of the solution approaches that of the distilled water (pH 5.5)

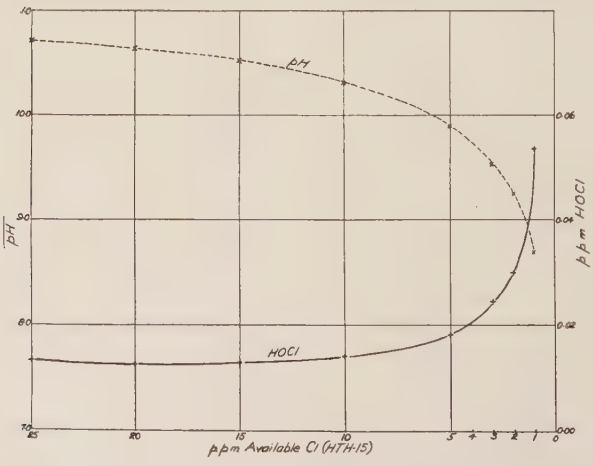

FIGURE 1. pH and HOCl concentration of HTH-15 solutions containing varying amounts of available chlorine.

81800–2½

TABLE 15.—COMPARATIVE GERMICIDAL EFFICIENCY OF VARIOUS CONCENTRATIONS OF HTH–15 AT 20° C. (PLATING AND GLASS SLIDE METHODS, MAY 23, 1934)

	p.p.m.	pH	Period of exposure (seconds)									
			20	30	40	50	60	70	80	90	105	120
Plating 1 cc. *(a)*	25	10.70	++++ ++++	+++ +++	++ ++	2500 est. 514	**84** **3**	21 0	9 2	1 0		
	10	10.28	++++ ++++	++ ++	350* +	2 +	**3** **26**	3 44	3 8	90 1350 est.	4 +	
	2	9.26		17 187	**6** **43**	4 18	4 13	1 36	3 336	2 21	2 13	0 3
	1	8.70		++++ ++++	++++ ++++	++++ ++++	++++ ++++	++++ ++++	++++ ++++	++++ ++++	++++ ++++	++++ ++++
Glass Slide *(b)*	25	10.70		+ +	+ +	+ +	+ 513*	527 7*	207 169	**74** **55**		
	10	10.28		+ +	+ +	+ +	+ +	+ ?	236 294	66 73		
	2	9.26		593 793	**70** **18**	3 122	9 118	0* 0*	0* 6	8 0		
	1	8.70		+ 93	+ 81	103 61*	+ 110	+ 165	+ +	+ +		

N.B.- *(a)* 9,050,000 per cc. in test solution for plating method; 99.999 per cent destruction leaves 91 colonies per cc. plated. Plus signs indicate density of growth.

(b) Glass slides averaged 25,000 per slide; 99.75 per cent destruction leaves 64 colonies per slide. Plus sign indicates >500 colonies.

*Count lowered by spreaders.

used in preparing the dilutions. However, under practical conditions the greater instability of the solution as the proportion of hypochlorous acid increases, and the loss of potency due to reaction with traces of organic matter make it inadvisable to employ too dilute solutions. It is hoped that further studies upon this phase of chlorine sterilization may be undertaken in the near future.

Discussion

The results presented in this paper indicate certain difficulties encountered in evaluating the germicidal potency of a series of hypochlorite solutions. This potency at 20° is clearly shown to be dependent upon both the concentration of available chlorine and the pH of the solution, or more specifically, upon the concentration of hypochlorous acid which is dependent upon these two. But although the chlorine concentration changes uniformly upon dilution this is not true of the pH value, because of differences in buffer capacity between various hypochlorite products[9] and because of the increasing rate of change of pH as the chlorine concentration approaches zero. Consequently the potency indicated by one technique may, in the case of certain products, be decidedly different from that by another, where a much greater or lesser dilution is employed. Furthermore, the introduction of an excess of organic matter, as in the F.D.A. method, unduly favours the organic chlorine compounds, while differences in speed of action between mildly and strongly alkaline hypochlorite solutions are greatly minimized. It might be mentioned at this point that the Food and Drug Administration of the United States Department of Agriculture hold the following view (*16*): "Neither the F.D.A. method of determining phenol coefficients nor any of the other coefficient methods with which we are familiar are suited to the examination of chlorine disinfectants." Instead, attention is chiefly directed to the content of available chlorine, although the depressive influence of excessive amounts of alkali is also taken into consideration in connection with the dilution recommended by the manufacturer.

At a given concentration of available chlorine, germicidal potency appears to vary directly with the decrease in hydroxyl ion concentration. Therefore, a simple method such as the indicator test described in this paper enables ready differentiation between hypochlorites of varying degrees of potency. Furthermore, this test may be applied on hypochlorite solutions of the exact concentration at which they are to be employed in plant practice, an advantage not enjoyed with most biological methods of disinfectant testing.

Where it is considered desirable to use a biological testing method, the glass slide method offers certain advantages over the methods generally employed. It approximates more nearly the conditions under which bacteria have to be destroyed (or removed) in plant practice in that the latter are present in a moist film of diluted milk upon a surface rather than being freely suspended in the disinfectant solution. It also allows any superiority in detergent action to exert an influence, a factor which may be of importance under practical conditions and at higher temperatures

[9] Because of this it is not feasible to employ a fixed period of exposure as recently suggested by Jensen (*9*) for phenol coefficient studies.

and which receives no consideration in the usual testing methods.[10] Furthermore, tests may be conducted on solutions of the strength used in the plant, thus avoiding erroneous impressions of the effectiveness of certain products as were obtained with the Burri slant method. Lastly, the method possesses great flexibility in that the concentration of the test organism and of chlorine, and the period of exposure to the latter, may be varied within wide limits. In no other method has it been possible to employ exposure periods of less than 8–10 seconds (*28*) while with the glass slide method an exposure of 1 second presents no difficulties.

It has been shown by Dole (*5*) and others that where the pH of a solution containing sodium ion is above 9.5 the observed E.M.F. with the glass electrode is no longer a linear function of the pH, and that the deviation increases with the concentration of sodium ion present in the solution. In preparing the calibration curves for the glass electrode in the present studies, buffer solutions of M/20 concentration were employed to obtain two points beyond pH 9.5, in addition to four other solutions between pH 3.97 and 9.15. Since the hypochlorite solutions tested contained a variety of sodium salts (carbonate, bicarbonate, phosphate, silicate, hydroxide), it is probable that the concentration of sodium ions in solutions above pH 9.5 would show some variation. It is unlikely, however, that such variations would be sufficiently marked to introduce any significant error because of the degree of dilution (100 p.p.m. available chlorine is 0.00283 N) of the solutions employed. While no claims are made for extreme accuracy in the pH values obtained, it is felt that they furnish a fairly satisfactory indication of the degree of alkalinity of the various products.

In the testing of certain products it was observed that the solution became more acid upon standing in a stoppered flask. In one instance this change occurred so rapidly that the pH had fallen from 10.62 to 10.12 within an hour. This doubtless explains certain slight discrepancies between the results obtained on some of the less alkaline products by the indicator test (Table 8) and by the glass electrode (Table 9). In the former, all solutions were prepared together so that all would enjoy approximately the same period of contact with the phenolphthalein powder before being arranged in order of increasing colour. In the glass electrode studies, each solution was prepared immediately before making the pH determination, as was the case in the germicidal testing. Most accurate results will therefore be obtained where tests are carried out upon dilutions freshly prepared from stock solutions.

From the data presented here it is evident that much still remains to be learned concerning the most effective concentration of hypochlorite solution for practical use. The results obtained with HTH–15 at various concentrations suggest that the pH value of the solution exerts a much greater influence than the concentration of available chlorine, especially in the more dilute solutions. While the distilled water used in these tests is much more acid than the majority of city water supplies, it would appear that the pH of the water employed to dilute the stock solution, as well as the pH of the latter, may need to be considered in deciding upon the most effective concentration for a given hypochlorite product.

[10] The new coverslip method of Jensen and Jensen (*9*) is perhaps an exception, although where the disinfectant is not kept in motion the detergent action is much less pronounced.

Summary

Several methods for evaluating the relative germicidal potency of hypochlorite products have been tested out. Two new methods, an indicator test for pH, and a biological test (with *Staphylococcus aureus* in a milk film upon a microscopic slide) have been developed which are considered promising.

The relative potency of a series of commercial products as determined by several methods is recorded. Discrepancies between the ranking of certain products at 2 and at 100 p.p.m. have been traced to differences in buffer capacity.

Data obtained by glass electrode studies indicate that the influence of the pH of the solution is even greater than that of the concentration of available chlorine, particularly in dilute solutions. This requires consideration in deciding upon the most effective concentration of available chlorine for use in plant practice.

Acknowledgments

The writer wishes to express his thanks to Dr. A. G. Lochhead, Dominion Agricultural Bacteriologist, for his advice upon various phases of the work; to Mr. A. H. Jones, B.S.A. for assistance with the germicidal testing, and to Mr. G. S. Field, M.Sc., National Research Council, Ottawa, for assistance in the design and construction of a vacuum tube potentiometer for glass electrode determinations.

Addendum

Since this paper was written, one has appeared by Devereux and Mallmann entitled "Studies of the Technic to Evaluate the Efficiency of Several Chlorine Sterilizers for Dairy Use". (J. Dairy Sci. 17, 351-360. 1934). The efficiency of two hypochlorites and one chloramine-T product, used at several concentrations as flush solutions in plant practice, was evaluated by three methods. Under the conditions of the experiment (solution in contact with plant equipment for seven minutes) no significant differences were observed between the two hypochlorites (Diversol and HTH–15). Delayed action was observed with the chloramine-T product (Wyandotte Sterilizer). These results emphasize the importance of the period of exposure to the sterilizing solution. Where this is sufficiently lengthy, differences in germicidal speed diminish in importance; where it is brief, as in can and bottle rinsing, they are much more significant. The statement that 6 to 11 p.p.m. of HTH–15 gave as efficient results as 60 to 79 p.p.m. is particularly interesting in view of the results reported in the present paper on the effect of dilution.

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RESUME

Evaluation de la puissance germicide des composés de chlore—I. Hypochlorites. C. K. Johns, Ferme expérimentale centrale, Ottawa, Ont.

Un certain nombre de moyens pour évaluer la puissance germicide relative des produits d'hypochlorite ont été mis à l'essai. De nouvelles méthodes, un essai d'indicateur pour le pH et un essai biologique (avec *Staphylococcus aureus* dans une pellicule de lait sur une plaque microscopique) ont été développées et donnent de l'espoir. On a noté la puissance relative d'une série de produits commerciaux, déterminée par plusieurs méthodes. Les différences constatées dans le classement de certains produits à 2 et à 100 p.p.m., ont été attribuées à des différences dans la capacité d'oxydation. Les données obtenues par l'étude d'électrodes de verre indiquent que l'influence du pH de la solution est encore plus considérable que celui de la concentration de chlore libre, surtout dans les solutions diluées. C'est là un facteur dont on doit tenir compte dans le choix de la concentration la plus utile de chlore libre pour l'emploi dans la pratique.

GRAVENSTEINS—TIME OF PICKING IN RELATION TO SPOT SCALD[1]

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[Received for publication April 4, 1934]

A spot scald disease affecting Gravenstein apples was described by Hockey [3] in 1931. In that paper it was suggested that the sucrose content of the fruit might have influenced the development of the scald symptoms. No fruit with a sucrose content over 0.1% was available at the time the scald appeared in the 1930 crop. It was therefore decided that observations on this condition should be made on the 1931 crop.

Materials and Methods

This "scald" has been observed on Gravenstein and Banks Gravenstein fruits following exposure to light after storage. For the 1931 observations a Banks Gravenstein tree was selected in an orchard which had received the ordinary routine cultural, fertilizer and spraying treatment. The fruit from this tree was picked at intervals of one week from August 26 until September 30, the date of the sixth and last picking. Approximately one bushel of apples was selected at each picking. The fruit was graded for uniformity of size and colour to represent the optimum condition of the fruit on the tree at the time of each picking. It was then placed immediately into common ventilated storage. Records were also taken on percentage colour, size, presence of starch and pressure test of each lot. Ten apples of each sample were used for the starch and pressure tests, and these were then peeled, cored and minced for sugar determinations.

Starch.—The iodine-potassium iodide test was applied to thin longitudinal sections of the fruit.

Pressure Test.—The modified Magness pressure tester manufactured by D. Baullauf Inc., Washington, D.C., was used throughout with the 7/16 inch tip. A thin peel was first removed before testing.

Sugars.—These were determined by the modified Fehling's solution method using the ferrocyanide test to determine the end point in titration. Total sugars were determined by inverting the sucrose in the juice with HCl and subsequently neutralizing with 2n. NaOH. The difference between total and reducing sugars was taken as sucrose.

Colour and Size of Fruit at Time of Picking

Notes were made on the relative amount of colour of each lot of apples, at the time of picking. The apples of the first three pickings had streaked colour only and no blush or solid coloured cheek. The apples of the last three pickings were more solidly coloured and streaked and were altogether typical of the variety, "Banks Gravenstein."

[1] Contribution No. 398 from the Division of Botany, Experimental Farms Branch, Department of Agriculture, Ottawa, Canada.
[2] Pathologist-in-Charge and Plant Disease Investigator respectively.
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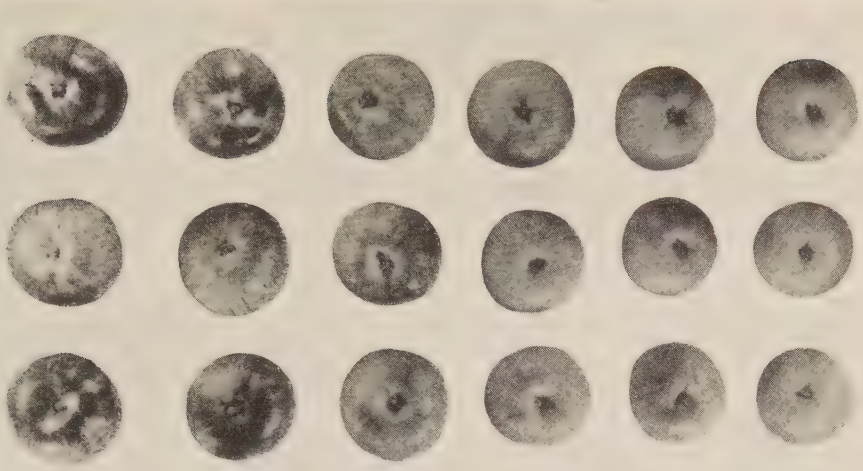

FIGURE 1. Typical size and colour intensity of Gravensteins of six successive dates of picking. Photographed October 27, 1931. Smallest apples are first picking.

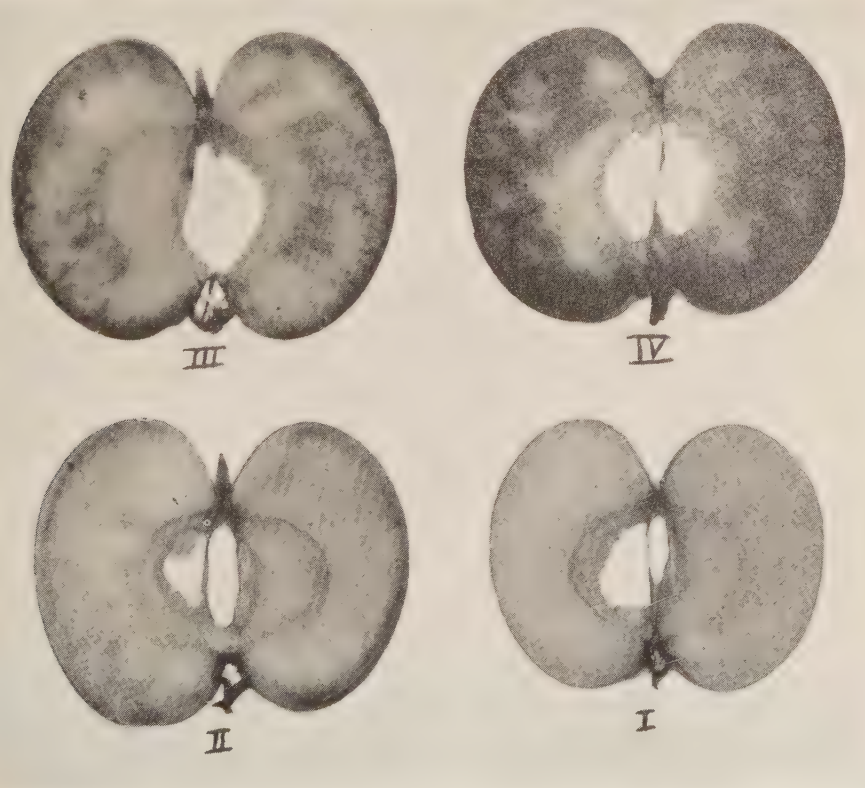

FIGURE 2. Iodine-potassium iodide test for starch photographed Sept. 16, 1931.
I. Picked August 26. II. Picked September 3.
III. Picked September 9. IV. Picked September 16.

The intensity of colour and average size of each lot of fruit at the time of picking is given in Table 1. Figure 1 shows representative samples.

TABLE 1.—SIZE AND COLOUR AT TIME OF HARVEST

Lot	Date picked	Average diameter	No. per brl.	Colour
I	Aug. 26	2.43	585	50% streak
II	Sept. 3	2.59	525	70% streak
III	Sept. 9	2.68	475	75% streak
IV	Sept. 16	2.81	435	80% streak and blush
V	Sept. 23	2.84	400	85% streak and blush
VI	Sept. 30	2.93	350	85% streak and blush

Climatic conditions are known to affect size and colour of fruit. Table 2 gives a summary of local observations on these conditions during harvest. The week preceding the time of harvesting sample IV had a high mean temperature, one day with a rainfall of 0.28 inch, and sunshine averaging close to 7 hours per day. These conditions, together with the decreasing starch content as shown below, apparently were favourable to the development of colour.

TABLE 2.—CLIMATOLOGICAL CONDITIONS DURING HARVEST

Period	Temperature in Degrees F.		Precipitation		Sunshine
	Range	Average of daily mean	No. of days	Total inches	Total hours
Aug. 26–Sept. 2	44° – 80°	63.7° (1)	1	0.85	61.7
Sept. 3–Sept. 8	47° – 75°	60.2°	5	1.33	20.5
Sept. 9–Sept. 15	42° – 86°	63.9°	1	0.28	48.0
Sept. 16–Sept. 22	34° – 65°	53.2°	4	0.63	36.1
Sept. 23–Sept. 29	43° – 64°	52.7°	6	1.72	10.7

THE STARCH TEST

Figure 2 shows the relative amounts of starch present in the fruits of the first four pickings on the day of the fourth picking, September 16. The fruit of the fifth and sixth pickings were similar to III, in Figure 2, at the time they were picked. The starch in the fruit of the first three pickings completely disappeared after three weeks in storage. The fruit of the last three pickings did not lose its starch until after four weeks in storage.

The starch content of the fruit at the time of picking was as follows:—

Lots I to III showed starch throughout the flesh;

Lot IV showed starch disappearing from the core area;

Lot V showed starch streaked in flesh, some in core area;

Lot VI showed starch scattered and streaked.

THE PRESSURE TEST

The average pressure in pounds as determined by the Magness pressure tester, on ten apples at the time of each sampling is given in Table 3.

TABLE 3.—AVERAGE OF PRESSURE TESTS ON GRAVENSTEIN APPLES

Date	I.	II.	III.	IV.	V.	VI.	Temp.
Aug. 26	17.2	—	—	—	—	—	66
Sept. 3	16.1	16.0	—	—	—	—	60
Sept. 9	15.1	15.1	14.6	—	—	—	58
Sept. 16	11.6	11.2	13.9	13.9	—	—	60
Sept. 23	11.4	9.2	10.3	12.9	12.7	—	55
Sept. 30	10.1	8.8	8.8	9.5	12.1	13.2	50
Oct. 7	9.9	8.7	9.3	9.7	10.0	11.3	48
Oct. 14	9.3	8.8	9.5	8.7	8.4	8.8	49
Oct. 21	10.7	8.6	8.4	7.7	7.1	7.1	42
Oct. 28	9.9	8.2	8.3	7.1	8.3	7.2	44
Nov. 4	9.5	8.8	7.8	7.2	7.8	7.5	44
Nov. 11	9.5	9.3	7.3	7.5	7.4	7.7	45
Nov. 18	9.2	8.3	7.5	7.4	7.3	7.8	41
Nov. 25	8.5	6.6	7.4	7.0	6.7	6.8	50
Dec. 9	8.6	7.4	7.5	7.9	7.2	7.1	31

By October 21 the fruit of the first two pickings was withered, and that of the third picking was in the same condition the following week. It was fully three weeks later before withering was found in the fruit of the last three pickings.

The pressure tester gives an indication of the firmness of the flesh. The iodine test for starch gives an indication of the physiological condition of the fruit. Fruit which showed the highest starch content and average pressure at time of picking wilted earliest in storage. A comparison of the pressure test and starch test can be made at the time each lot of apples became free from starch. The average tests at this time were 11.6; 9.2; 8.8; 8.7; 7.1; and 7.2 pounds respectively for Lots I to VI. It is evident that firmness of flesh and starch content cannot be used synonymously. The firmness of the flesh varies on the same apple. The coloured side of a fruit will frequently require two pounds more pressure than the green portions. Furthermore, the accuracy of readings from the pressure tester depends on the skill of the operator. The iodine test is a visual black and white test, fool-proof and an indication of the starch content. Since starch gradually disappears in an apple approaching maturity the test for starch is considered a more reliable index of physiological maturity.

SUGAR CONTENT DURING STORAGE

Sugar analyses were made weekly on samples from storage of each picking until November 25. From these analyses it was found that total sugar increased in the fruit until the iodine test gave a negative reaction for starch. After the disappearance of starch, sucrose and total sugars gradually decreased. Total sugars were higher in Lots III and IV than any other sample. Lot IV maintained the highest sucrose and total sugar content throughout the storage period.

PRODUCTION OF SPOT SCALD

The first exposure of apples to light to determine their relative susceptibility to spot scald was made on October 7, one week after the last picking. One and one-half hour after exposure to sunlight in a window the fruit from the first two lots showed scald symptoms. Six hours after exposure all the fruit from the first three lots showed typical spot scald. Twenty-four hours later one apple from Lot V had a few very small spots at the stem end. After forty-eight hours' exposure two apples in Lot VI had a few very small spots. The spots were depressed on all fruits. Lot IV was the only one which developed no scald symptoms.

Table 4 presents the sugar analyses made at the time of the first exposure of the apples to light. Lot IV had the greatest amount of reducing and total sugars and developed no spot scald. On the other hand, Lot VI developed the least spot scald and had the lowest amount of total sugar. Lots I, II and III developed symptoms of the disease a few hours after exposure and there is an appreciable difference in sucrose and total sugar content of the first two and third pickings.

TABLE 4.—SUGARS IN GRAVENSTEINS. OCTOBER 7, 1931.

Lot	Reducing	Sucrose	Total
I	7.64	0.26	7.92
II	7.59	0.37	7.96
III	7.30	1.49	8.79
IV	8.33	1.45	9.78
V	6.37	1.69	8.06
VI	6.54	1.24	7.78

A similar exposure of fruit to light was attempted two weeks later. The weather was very dull and sunlight totally lacking. After forty-eight hours' exposure all the fruit from all lots except No. IV had developed the trouble. In the latter only the poorest coloured fruit showed scald. It may be noted here that in these tests, apples from Lot IV were less waxy than any of the others.

A subsequent exposure of fruit from the six pickings gave the same results as the two above experiments, namely, that fruit from samples I, II, and III developed much more spotting than from the other three, and fruit from Lot IV was the least affected.

DISCUSSION

The data presented above do not show conclusively that any one factor under observation was directly responsible for the predisposition of the fruit to spot scald. At the time of the first exposure of the samples to light the first three lots were the only ones containing no starch. When the second exposure was made no fruit was found to contain starch. The fruit in Lots I and II contained less than 0.4% sucrose in the first exposure compared to 1.2 to 1.7% in the other four lots. Results from subsequent determinations of sucrose and total sugar content did not support the hypothesis that these have any influence on the susceptibility to scald.

The differences in colour intensity between the first three samples and the last three samples coincides inversely with the intensity of spot scald symptoms.

One sample of Gravenstein was obtained, from a local warehouse, which had been in cold storage four weeks. The fruit had been grown in

an orchard under sod culture and sprayed with lime sulphur, and had been picked on September 25 and stored a week later. This fruit spotted on exposure to light equally as much as the fruit from sample III. It was better coloured than the latter sample, being practically equal to Lot IV in this respect. Analysis for total sugar and sucrose showed a condition almost identical with that of fruit from Lot V. The fruit was firm and free from starch. It was apparent that cold storage did not prevent the appearance of the scald symptoms.

Tiller[4] described a similar condition occurring in New Zealand, and also in England, on fruit which had been exposed for sale in shop windows, as that reported here. Early picking and storage at 32° F. are suggested as partial controls for the Lord Wolseley variety. He concludes that "the spotting is a photo-chemical effect, and not a temperature effect." In a previous paper (loc. cit.) the writer stated "it is probable that a photo-chemical reaction is at least partly responsible for the symptoms."

There is considerable commercial significance to the data presented in this paper. When size, colour, and sugar content are considered there is a decided difference between the fruit from the first and the fourth pickings. Three more weeks on the tree greatly increased the quality of the crop.

Summary

1. Gravensteins picked at the time when most of the starch had disappeared from the core area and while there was an appreciable amount in the flesh of the apple, developed the least amount of spot scald.

2. The amount of sucrose and total sugars present in the fruit had little or no effect on the prevalence of the disease.

3. Harvesting the fruit when most of the starch had disappeared from the core area gave fruit of larger size, deeper colour and better keeping quality than earlier picked fruit of the variety Gravenstein.

4. The iodine-potassium iodide test for starch is considered superior to the mechanical pressure tester as a method for determining the picking maturity in apples maturing about the same time as Gravensteins.

RESUME

Pommes Gravenstein—Effet de la date de la cueillette sur l'échaudure. J. F. Hockey et J. A. Boyle, Laboratoire fédéral de pathologie végétale, Kentville, N.-E.

Une échaudure qui affecte les pommes Gravenstein a été étudiée. On voulait voir si la proportion de sucrose dans le fruit exerce une influence sur le développement de la maladie. Les pommes qui ont développé le moins d'échaudure sont celles qui ont été cueillies au moment où la plus grande partie de l'amidon avait disparu de la région du cœur, et lorsqu'il y en avait une quantité appréciable dans la chair de la pomme. La quantité de sucrose et de sucres totaux présente dans le fruit n'avait que peu ou point d'effet sur la fréquence de la maladie. Les fruits récoltés lorsque la plus grande partie de l'amidon avait disparu de la région du cœur étaient plus gros, avaient une couleur plus foncée et se sont conservés mieux que les fruits cueillis plus tôt. On considère que l'essai d'iodure de potassium pour l'amidon est supérieur à la pression mécanique comme moyen de déterminer le degré de maturité pour la cueillette, dans les pommes qui mûrissent à peu près en même temps que les Gravensteins.

[4]Tiller, L. W.—A superficial spotting disease of the Lord Wolseley Apple. N.Z. Jour. Sci. Tech. *14*; 2: 111-113. 1932.

A NOTE ON THE VITAMIN A AND D CONTENT OF OIL FROM THE TESTES OF A STURGEON[1]

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[Received for publication May 7, 1934]

A lake sturgeon[2] (*Acipenser fulvescens*) caught in Lake Ontario in the summer of 1928 was kept at room temperature for a few days, during which time a very large quantity of oil oozed from the testes of the fish. This oil was collected and filtered through Chardin paper. It was reddish brown in colour and had a rather acrid odour. The vitamin content of this oil was assayed but unfortunately the liver was not available.

Vitamin A Assay

1. *Biological.*—The vitamin A potency of this oil was assayed by the technique of Sherman and Munsell (*3*). The oil was fed in daily doses of 0.02, 0.04, 0.06, 0.08 and 0.16 grams after cessation of growth. Vitamin D was supplied by viosterol (irradiated ergosterol). All rats fed these various amounts continued to lose weight but the larger doses definitely prolonged the survival period. The oil had no curative influence on xerophthalmia.

2. *Colorimetric.*—The oil was colorimetrically assayed for vitamin A potency by the technique recommended by the Accessory Food Factors (Vitamins) Committee (*1*). A faint blue colour, less than one unit, was developed.

This oil, although probably containing a very small amount of vitamin A, was for all practical purposes, devoid of the vitamin.

Vitamin D Assay

The antirachitic potency of the oil was estimated by the preventive type of assay, previously described (*2*), using Steenbock's rachitogenic diet 2965. The findings are summarized in Table 1.

Table 1.—Antirachitic potency of sturgeon testes oil

Diet	X-ray findings	Inorganic phosphate in plasma (P. in mgs. per 100 cc.)
Normal	Normal	5.2
Rachitogenic No. 2965	+Rickets	1.8
Rachitogenic + .02g. oil	+Rickets	1.8
Rachitogenic + .01g. oil	+Rickets	2.1
Rachitogenic + .004g. oil	++Rickets	1.7

These results showed that this oil contained extremely little, if any, vitamin D.

Since this oil was a sample from one fish only no general conclusion can be made as to the presence or absence of vitamins A and D in the testes of the ganoids. The fish was apparently in normal condition. Many

[1] A contribution from the Department of Biochemistry, University of Toronto, and the Department of Poultry Husbandry, Ontario Agricultural College.

This work formed part of a thesis submitted by the author for the degree of Doctor of Philosophy, in the Department of Biochemistry, University of Toronto.

[2] This material was kindly supplied by the Ontario Fisheries Research Laboratory.

investigators have established the presence of vitamin D in the body as well as the liver oils of a number of fish, of both salt- and fresh-water habitat. Zilva, Drummond and Graham (*4*) found oil from the gonads of codfish to be very potent in vitamin A. If the absence of fat-soluble vitamins in the ganoids can be substantiated, a further investigation of the potency of oils from various fish families might give results indicating that vitamin D may be synthesized in the tissues of fishes and that the ability to synthesize the vitamin is confined to particular types.

Summary

The oil from the testes of a sturgeon (*Acipenser fulvescens*) is shown to be devoid of vitamins A and D.

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BOOK REVIEWS

SUPPRESSION OF WEEDS BY FERTILIZERS AND CHEMICALS. H. C Long, B.Sc. (Agric.) of the Ministry of Agriculture and Fisheries. Published by H. C. Long, "The Birkins," Orchard Road, Hook, Surbiton, Surrey, Eng. March 1934. Price 2s. net.

In recent years many experiments have been conducted in different parts of the world in order to study the effect of certain chemical substances on the control of weeds. Mr. Long in his book "Suppression of Weeds by Fertilizers and Chemicals" has given a concise and useful summary of the more important results obtained from these experiments.

Sir A. D. Hall in the foreword to this booklet says 'Mr. Long has been at great pains to sift the voluminous literature which is scattered throughout many periodicals, foreign as well as English. He has put the data into a practical form and provided references for those who wish to consult the original papers."

Very useful data are presented in the first chapter of this booklet to show the great difference in yield between clean and weedy crops. The loss of crop yield due to weeds is frequently 40 to 50 per cent.

The chapters dealing with commercial fertilizers are most interesting. Many outstanding results are recorded which show the marked influence of ammonium sulphate, calcium cyanamide, finely ground kainit and lime on the control of certain weeds.

The effects of sulphates of copper and iron, sodium and potassium chlorates, compounds of arsenic and a number of other chemicals on the suppression of weeds are also discussed.

The booklet contains numerous illustrations which show in a striking manner the effect of certain chemical substances on the control of weeds. —Geo. Knowles

BUMBLEBEES AND THEIR WAYS. Otto Emil Plath. The Macmillan Company of Canada. 1934. Price $4.75.

This volume forms a fascinating addition to our knowledge of this interesting group, supplementing the researches of Sladen and Hoffer on the habits of the European species of this family. As stated by Dr. W. M. Wheeler, "It fulfills the function of an accurate taxonomic guide on our common North American species and constitutes, in its emphasis on the behavior pattern of each species, an outstanding example of the many up-to-date contributions with which the younger entomologists are steadily enriching their science." The volume embodies the work of thirteen summers devoted to observation and experiment in an effort to solve the many interesting problems that this group presents. The impressive amount of new material which the author has managed to compress into his book is pleasingly presented in non-technical language which makes it of equal interest to the entomologist and the nature student. —W. H. Brittain

THE ECONOMIC ANNALIST

A REVIEW OF AGRICULTURAL BUSINESS PREPARED QUARTERLY BY THE AGRICULTURAL ECONOMICS BRANCH, DEPARTMENT OF AGRICULTURE, OTTAWA

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THE ECONOMIC SITUATION

PREPARED IN THE AGRICULTURAL ECONOMICS BRANCH, DEPARTMENT OF AGRICULTURE, OTTAWA, FROM BASIC DATA COLLECTED BY THE DOMINION BUREAU OF STATISTICS

The index number of wholesale prices in Canada was unchanged at 71.1 in May. The sub-indexes of vegetable products; wood, wood products, and paper; iron and its products; chemicals and allied products advanced, whereas those of animals and their products; fibres, textiles, and textile products; non-ferrous metals and their products, and non-metallic minerals declined.

Retail Prices.—The total index of retail prices, rents, and costs of services declined from 79.6 in April to 78.7 in May. The food index dropped from 71.0 to 68.6. The fuel index advanced slightly but the index of rentals was 79.7 as compared with 80.4 in previous months. The latter index is computed only at October 1 and May 1.

Retail Sales.—The value of retail sales was lower in April as compared with March. The index therefore fell from 73.6 to 72.1 (1929 = 100), although it should be remembered that the March index was affected by Easter business. Groceries and meats moved downward from 83.0 to 75.1. Candy sales dropped from 93.0 to 66.5. Sales in general and departmental stores declined from 66.8 to 65.2. On the other hand the index of the value of boot sales rose from 70.1 to 76.5; that of clothing advanced from 87.4 to 92.9 and hardware from 72.1 to 104.3.

Physical Volume of Business.—The indexes of physical volume of business, industrial production, agricultural marketings and cold storage holdings are not available as this is being written. The reader is referred to the table of indexes for changes which may have taken place.

Agricultural Products.—The index of wholesale prices of Canadian farm products advanced from 55.4 in April to 56.9 in May. Field products rose from 48.7 to 51.1. Higher prices for grains contributed largely to this advance. The average price of No. 1 Manitoba Northern wheat was 70.6 cents in May as against 65.5 cents in April. Similarly prices of No. 2 C. W. oats were 34.6 and 32.4 cents respectively. No. 1 C. W. flax was 157.3 as compared with 149.7. No. 2 C.W. rye was 46.4 in May as against 44.1 in April, while No. 3 C. W. barley averaged 38.1 and 36.9 cents in the respective months. The index of animal products receded from 66.6 to 66.5. Lower prices for wool and fresh milk chiefly affected this index. Prices of cattle were also lower but those of hogs and lambs advanced. Egg prices at Montreal, Toronto and Vancouver were higher than in April. Butter prices generally were lower.

Cold Storage Holdings.—Cold storage holdings of creamery butter on June 1 were 7.6% above the five year average at that date. Stocks of cheese were 10.6% higher than the average. Supplies of cold storage eggs on the other hand were 11.7% lower. Total stocks of pork were 16.8% below the average. Holdings of beef were 12.6% under and those of veal 10.8% less than the five year average. Supplies of poultry in storage were 4.4% lower.

ANNUAL AND MONTHLY INDEX NUMBERS OF PRICES AND PRODUCTION COMPUTED BY DOMINION BUREAU OF STATISTICS

Year	Wholesale Prices 1926 = 100				Retail prices and cost of services (5)	Production (6) 1926 = 100			
	All commodities (1)	Farm products (2)	Field products (3)	Animal products (4)		Physical volume of business	Industrial production	Agricultural marketings	Cold Storage holdings
1913	64.0	62.6	56.4	77.0	65.4				
1914	65.5	69.2	64.9	79.0	66.0				
1915	70.4	77.7	76.9	79.2	67.3				
1916	84.3	89.7	88.4	92.3	72.5				
1917	114.3	130.0	134.3	119.6	85.6				
1918	127.4	132.9	132.0	134.7	97.4				
1919	134.0	145.5	142.4	152.5	107.2	71.3	65.5	48.1	47.1
1920	155.9	161.6	166.5	149.9	124.2	75.0	69.9	52.6	94.2
1921	110.0	102.8	100.3	108.5	109.2	66.5	60.4	65.2	86.4
1922	97.3	86.7	81.3	99.1	100.0	79.1	76.9	82.6	82.8
1923	98.0	79.8	73.3	95.1	100.0	85.5	83.8	91.4	87.6
1924	99.4	87.0	82.6	97.2	98.0	84.6	82.4	102.5	114.9
1925	102.6	100.4	98.1	105.7	99.3	90.9	89.7	97.2	108.6
1926	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.9	100.0
1927	97.7	102.1	99.9	105.7	98.4	106.1	105.6	103.6	110.0
1928	96.4	100.7	92.6	114.3	98.9	117.3	117.8	146.7	112.8
1929	95.6	100.8	93.8	112.5	99.9	125.5	127.4	101.1	109.6
1930	86.6	82.3	70.0	102.9	99.2	109.5	108.0	103.0	128.4
1931	72.2	56.3	43.6	77.6	89.6	93.5	90.4	99.0	125.7
1932	66.7	48.4	41.1	60.7	81.4	78.7	74.0	114.3	120.1
1933									
Jan.	63.0	43.6	35.1	57.9	79.1	68.1	62.2	56.1	112.0
Feb.	63.6	43.0	36.0	54.7	78.4	67.0	60.0	76.5	127.6
Mar.	64.4	44.7	38.0	56.0	77.8	68.4	62.5	129.0	135.8
April	65.4	46.8	41.1	56.4	78.1	69.8	65.1	104.1	112.7
May	66.9	51.2	46.9	58.4	77.0	76.4	72.7	95.4	110.4
June	67.6	52.6	49.4	57.9	77.0	82.2	79.8	221.9	119.9
July	70.5	60.1	60.8	59.0	77.2	84.1	82.6	221.9	119.9
Aug.	69.4	57.0	54.9	60.5	78.6	89.8	89.5	197.2	114.2
Sept.	68.9	54.7	49.5	63.4	78.8	90.8	90.2	101.1	115.7
Oct.	67.9	51.4	44.6	62.8	77.9	88.2	87.4	70.5	112.7
Nov.	68.7	53.8	46.7	65.8	78.1	85.5	83.9	41.8	111.1
Dec.	69.0	53.3	45.3	66.6	78.4	86.2	85.1	30.7	107.6
1934									
Jan.	70.6	55.3	47.9	67.8	78.7	86.8	84.5	48.2	108.1
Feb.	72.1	58.0	49.3	72.5	79.2	86.4	84.0	67.1	98.6
Mar.	72.0	56.5	49.5	68.3	80.2	93.1	92.0	63.8	97.0
Apr.	71.1	55.4	48.7	66.6	79.6	92.6	91.4	56.9	94.5
May	71.1	56.9	55.4	66.5	78.7	99.6	99.4	130.6	102.6

1. See Prices and Price Indexes 1913-1928, pp. 19-21, 270-289 and 1913-1931, p. 15.

2. Wholesale prices of Canadian products of farm origin only. See Prices and Price Indexes 1913-1931, p. 33, and Monthly Mimeographs 1933 and 1934.

3. Wholesale prices of grains, fruits and vegetables.

4. Wholesale prices of Animals and Animal Products.

5. Including foods, rents, fuel, clothing and sundries, See Prices and Price Indexes 1913-1928, pp. 181-185, 290-293. 1926=100.

Prices and Price Indexes 1913-1931, p. 122, and Monthly Mimeographs 1933-1934.

6. Monthly Review of Business Statistics, p. 8, and Monthly Indexes of the Physical volume of business in Canada, supplement to the Monthly Review of Business Statistics, November, 1932.

Crops.—Crop prospects improved as a result of the general rains during the second week of June. The effect of drought in sections of Eastern Canada are, however, still apparent. Conditions in the Prairie Provinces have become more hopeful although drought, soil drifting, and grasshoppers have all affected cereal production.

Dairy Production.—The Dairy News Letter, June 15th, gives the gradings of cheese from December 4, 1933, to June 2, 1934 as 87,761 boxes as compared with 118,279 boxes graded during the period November 28, 1932, to June 3, 1934.

Production of butter for the four months ending April 30, 1934, was 39,766,747 pounds as against 38,185,326 pounds during the first four months of 1933, an increase of 4.2%. Among the provinces, Prince Edward Island and Saskatchewan show decreases of 2.0 and 5.3% respectively. In New Brunswick production increased 48.6%. Nova Scotia creameries increased output 13.2% and in Manitoba production was 6.1% higher. In Alberta and Quebec output was slightly over 5% above that in 1933.

Prices in Great Britain.—The Board of Trade index number of wholesale prices (1913 = 100) was 103.8 in March compared with 97.6 in March, 1933. This index did not fluctuate a great deal in 1933; it rose from 97.2 in April until February, 1934, when it reached 105.3. The cost of living index computed by the Ministry of Labour was 139 in April of this year whereas in April, 1933, it was 137. The peak during the past twelve months was reached in December when this index was 143.

The index of prices of agricultural products (1911-1913 = 100) in Great Britain was 108 in March of this year as compared with 102 in March, 1933. During 1933 this index varied from 100 in June to 109 in December. It rose to 114 in January, 1934, but receded to 112 in February and fell another 4 points in March. The importance of this market for Canadian agricultural products emphasizes the necessity of close examination of price movements in Great Britain.

SASKATCHEWAN MILK ENQUIRY, 1933

The report of the Saskatchewan Milk Enquiry Commission prepared by Dr. Wm. Allen of the University of Saskatchewan, indicates that the problems affecting the marketing of fluid milk in Saskatchewan, except for local conditions, do not differ greatly from those in other provinces. Local differences, such as shortage of feed supplies, cause production costs to be high in some localities and have placed farmers in a precarious position. Surplus milk, which sometimes reaches 50% of the total milk supply, is a most serious factor in the marketing situation. Surplus of plants and general facilities for milk distribution causes costs of marketing to be high and reduces the price the producer receives. Milk distributors are confronted not only by the problem of maintaining a sufficient volume of milk to operate economically but also by the cost of special services given, bottle losses and bad debts. Incomplete enforcement of public health regulations in many localities is causing trouble and is bound to cause more trouble in the future if it continues.

In order to cope with the present situation, the commission advises that the powers of the Local Government Board be extended to include the regulation and control of the production, distribution and marketing of the milk supplies of the cities of the province along lines similar to those authorized in the Provinces of Manitoba and Alberta, the costs of this regulation and control to be borne by the industry.

It is recommended that power be given the Local Government Board to demand standard reports at regular intervals from distributors of market milk to facilitate current examinations of the distribution system.

It is also suggested that local authorities should attempt more rigid enforcement of health regulations, where enforcement is lax. Failing this it is proposed that provincial legislation be set up to take over the control of inspection and licensing of farms producing milk for city consumption, and of plants and agencies handling milk.

Because of the wide variation in quality of milk supplied to the cities and the need for securing a safer milk supply, and because the institution of uniform or similar standards and regulations throughout the market milk industry of the prairie provinces would be highly beneficial, the authorities responsible for the supervision of the production and distribution of milk in Saskatchewan should co-operate with authorities in Manitoba and Alberta in studying this matter fully and making such recommendations as may be warranted with a view to securing appropriate action.

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THE NATURAL PRODUCTS MARKETING ACT, 1934

J. F. Booth[1]

The Natural Products Marketing Act, which received third reading in the House of Commons, Ottawa, on June 7th, is an attempt to give to Canada legislation similar to that at present found in the statutes of the United Kingdom, Australia, and other parts of the Empire. Legislation giving some degree of control over marketing of such products, mainly agricultural, is also to be found in most of the countries of Europe, as well as in other parts of the world. Of necessity, such legislation differs, but a survey of the principles involved leads definitely to the conclusion that underlying all such efforts is the intent to regulate or control either by organizations set up with government sanction or by boards or commissions operated by the state.

It is to be expected that legislation of this nature introduced in Canada would differ to some extent from that to be found elsewhere. In many respects, however, the Canadian Act, if it becomes law in its present form, will resemble the enactments of the United Kingdom and of Australia. In some respects, too, it resembles legislation that was in effect in British Columbia for several years and which was ultimately declared ultra vires because it conferred authority which the courts held was not within the jurisdiction of the provincial legislature.

Products to be Dealt With.—It was considered desirable to make the provisions of the Natural Products Marketing Act broad enough to cover, in addition to agricultural products, such products as lumber and fish. The section dealing with this matter definitely specifies most of our major, and some of the less important, agricultural products and states that such other natural products of agriculture and of the forest, sea, lake, or river and any article of food or drink that is wholly or partly manufactured or derived from any such product may be made subject to the provisions of the Act by the Governor in Council. It is not intended that the Act will deal with secondary products other than those classified as food or drink.

Administration.—The Act is to be administered by "the Minister designated by the Governor in Council". This is understood, following a statement made in Committee of the House, to mean the Minister of Agriculture.

Machinery of Regulation.—The Act provides for a board to be known as the Dominion Marketing Board which is to consist of such number of persons as the Governor in Council may from time to time determine. The Board may employ professional and technical assistants, and shall be a body corporate with head office at Ottawa. It shall advise the Minister on matters pertaining to the Act and regulations made thereunder.

The Dominion Board, referred to in the Act as "the Board", will be financed out of monies to be appropriated by Parliament. In addition to the funds necessary for this purpose it is also provided that Parliament may make available money to assist in the organization of local boards and to meet expenditures incurred in connection with certain operations in the nature of marketing or regulation of marketing that may be undertaken by the Dominion Board in accordance with authority conferred by a special section dealing with this matter.

In addition to the Dominion Board, the Act provides for the setting up of local boards which will be the creation of persons engaged in production and/or marketing of a natural product. Any group of persons engaged in either or both of the functions above mentioned may petition the Governor in Council to approve a "scheme" for the regulation of the marketing of a natural product. The Minister upon receipt of the petition will refer it to the Dominion Marketing Board with a request that the Board consider the expediency thereof. It is assumed that the Board will consider and investigate the desirability of such an undertaking. If the Board reports favour-

[1]Commissioner, Economics Branch, Department of Agriculture, Ottawa.

ably upon the proposal, the Minister may then recommend its approval either with or without a vote of those who will be directly affected by its operations. The decision by the Minister on whether or not a poll will be required is to be based upon the question of whether those submitting the petition in the first instance adequately represent all persons whose activities will be subject to the regulations of the local board.

The scheme, which is the instrument designed to give effect to the wishes of those concerned with the production and/or marketing of the product to be dealt with, must state in sufficient detail all of the powers that are desired and which may be conferred within the scope of the Act, the arrangements for a poll, if one is proposed, the geographical limits of the territory to be included, whether the scheme is to relate to all of the regulated product or only to such part as enters inter-provincial or export trade, the number of persons who shall comprise the local board and the basis of their selection, and such other information as may be required by the Minister. The language used in dealing with the scheme, and with the local board that will administer it, clearly indicates that the intention is to give to those interested an opportunity to regulate their own business under stated conditions. The local board in charge of the scheme will be subject to the general supervision of the Dominion Marketing Board.

Powers Conferred.—The powers conferred by the Act are vested in the Dominion Board with the provision that the latter may delegate to a local board such of its powers as may be requested by a scheme. It is not intended that these powers will be used by the Dominion Board when a local board has been established or when producers or marketers of the product in question are in a position to create a local board. The Act does provide, however, that under conditions that might be referred to as unusual, and where no local board exists, the Dominion Board may undertake the regulation or the marketing of a product in interprovincial or export trade and that it may engage in such activities directly or in co-operation with local boards or through any agency which it may establish. A careful reading of this provision of the Act, and consideration of it in relation to the legislation as a whole, makes it quite clear that the powers thereby conferred are not to be used under ordinary circumstances. In his presentation of the Act to Parliament, the Minister made it plain that it was not intended to use this provision to force an organization on an unwilling group or as a substitute for local action.

With respect to the powers conferred by the Act it is significant that they relate only to the regulation of marketing, except in a case such as referred to where action is taken by the Dominion Board. Local boards will be given power to "regulate the time and place of marketing the regulated product, and to determine the manner of distribution and the quantity and quality or grade of the regulated product that shall be marketed by any person at any time, and to prohibit the marketing of any of the regulated product of any grade or quality." In this clause is embodied the fundamental principle of the legislation, namely, that of regulation with governmental approval. It is not intended that local boards shall engage in the buying or selling of products, nor that they shall disrupt organized trade.

In carrying out the powers conferred by the section quoted, a local board may provide for; (1) the conduct of a pool; (2) the compensation of persons who sustain losses under specified conditions; (3) the provision of facilities for processing or otherwise conditioning the regulated product, and (4) assistance in the conduct of research work. The local board, in the conduct of its operations, may co-operate with any board or agency established under the law of any province.

To enable it to enforce the authority which it exercises, the local board may require the registration or licensing of all persons engaged in the production or marketing of the regulated product. The term "regulated product", as defined by the Act, means a natural product to which a scheme approved under this Act relates.

Constitutional Authority.—Provision has been made that the Dominion Board may authorize any marketing board or agency established under the law of a province to be, and to exercise the functions of, a local board under the terms of the Natural Products Marketing Act and the Board may further exercise, or confer upon a local board established under the Act authority to exercise, any power conferred upon it by or pursuant to provincial legislation. Under such a provision a local board created either under the jurisdiction of a province or under the Natural Products Marketing Act may be given the authority to deal with both intra and inter-provincial marketing.

Financing of Local Boards.—Authority is granted by the Act for the collection and disbursement by a local board, as agent of the Dominion Board, of such funds as may be necessary for the conduct of its operations. A local board established under the law of any province may be granted the same authority. The monies necessary for the administration of a scheme may be raised by the imposition of charges or tolls against the regulated product.

Special Powers to Market.—Reference has already been made to the special powers given the Dominion Board to market or to regulate the marketing of a natural product. The limitation on this power is that there shall be no existing local board available for that particular product, and further that the Dominion Board shall be concerned only with interprovincial and/or export trade. Under such circumstances, and if the Minister is satisfied that the conditions of marketing are such as to warrant action, he may authorize the Dominion Board to act accordingly.

Restriction of Imports and Exports.—The provisions of the British Marketing Act of 1933 find their counterpart in Section 12 of the Canadian legislation which empowers the Governor in Council to regulate or restrict the importation into Canada of any natural product that enters Canada in competition with a regulated product. The Dominion Act, however, goes a step farther in this respect,—it also permits the Governor in Council to make orders or regulations to regulate or restrict the exportation from Canada of any natural product.

The provision with respect to exports, since it refers to "any natural product," is broader than that applied to import trade.

Investigation and Spreads.—There is a second part to the Act which is only indirectly related to the first part. It deals with "investigations" and "spreads." A spread, as briefly defined, is the charge made by any person for selling, storing, packing and conditioning a natural or regulated product. It also includes the difference between the price at which a natural product is purchased and the price at which it is sold, and in the case of a product that has been processed or converted into another form, it includes the difference between the price of the natural product and the sale price of the product resulting therefrom.

It is provided that the Minister may, at the request of the Board or upon his own initiative, authorize an investigation into the cost of production, wages, prices, spread, trade practices, and other matters relating to the production and marketing of a natural or regulated product, or any product derived therefrom.

If, as a result of an investigation which, it is inferred, may be conducted by officers of the Government, the Minister believes that a further inquiry is necessary he may appoint a committee representative of producers, persons engaged in the marketing, and consumers, to conduct such an inquiry. A committee so appointed shall have the powers of a commissioner appointed under the Inquiries Act and may investigate all operations occurring in connection with or in the course of marketing, adaptation for sale, processing, or conversion of a natural or regulated product for the purpose of ascertaining the spread that is received by any persons in the course of such operations. The committee may after investigation report whether in its opinion the spread received is detrimental to or against the interests of the public

—*Continued at bottom of page 32*

MILK CONSUMPTION IN MINNEAPOLIS

The results of a survey of milk consumption in Minneapolis conducted in 1934 were reported in "Minnesota Farm Business Notes," May 20, 1934. This report was prepared by W. C. Waite and R. W. Cox.

Data on milk consumption were obtained from 2,187 Minneapolis families who were located in 230 widely scattered areas and represented a good cross section of the city. Per capita milk consumption was found to be 0.85 pint per day. Studies in other cities indicated that per capita consumption was 0.77 pint in Philadelphia (1929), 0.72 pint in Newark (1920), and 0.85 pint in Boston (1930). The figure for Minneapolis is significant considering that studies in other cities were made in more prosperous times.

A greater proportion of milk was used for liquid consumption as the rate per capita increased; for example, in families consuming at rates between 0.4 and 0.8 pint per day per person, 52% of the milk was used for drinking, while in the families consuming at rates between 1.2 and 1.6 pints, 64% was used for liquid consumption.

Income did not appear to have as great an influence on milk consumption as it does on the other dairy products. Nearly all families, regardless of income levels, reported the purchase of fluid milk Moreover, per capita consumption did not vary greatly except in the lowest income classification when it was 0.77 pint per capita as compared with 1.00 pint per capita in the group showing the highest rate of consumption. The slight decline in the highest income group probably was due to the greater consumption of cream in that group (Table 1).

The differences in consumption which appear in Table 1 may be explained by the fact that in the lower income group fewer adults were drinking milk than in the high income classification. This tendency was even more marked in the group of relief families. A probable source of an increase in milk consumption therefore lies in persuading adults, particularly in the low income groups to drink milk. An increase in the income of the lowest group may be expected to slightly increase milk consumption by the children, and would probably materially increase the consumption by adults.

TABLE 1.—PER CAPITA CONSUMPTION OF MILK AT VARIOUS INCOME LEVELS, MINNEAPOLIS, 1934

Per capita income	Per capita consumption pints per day
Under $300	0.77
$300–$599	0.93
$600–$899	1.00
$900 and above	0.97
Relief families	0.69
All families	0.85

Presence of children in the family is naturally an important factor in milk consumption. For example, in families with two adults and no children per capita consumption averaged 0.95 pint per day, while in families of two adults and two children per capita consumption averaged 1.04 pints per day.

In all income levels, more was spent for fluid milk than any other dairy product. Over 50% of the expenditure on dairy products in the low income group was used for the purchase of fluid milk. This declined to 36.5% in the highest income group. In terms of butterfat, however, fluid milk is not so important, accounting for 26.7% of the intake in the low income group and 20.4% in the high income group. On all income levels, butter was over twice as large a source of butterfat.

As per capita income increased, expenditures on dairy products increased, but at a less rapid rate than other food costs and the proportion of the dollar expended for food which was spent on dairy products declined. There was a decrease from an expenditure of about 30% of the total food costs in the lowest income group to 22% in the highest income group.

ASSESSMENT OF FARM PROPERTY IN ONTARIO

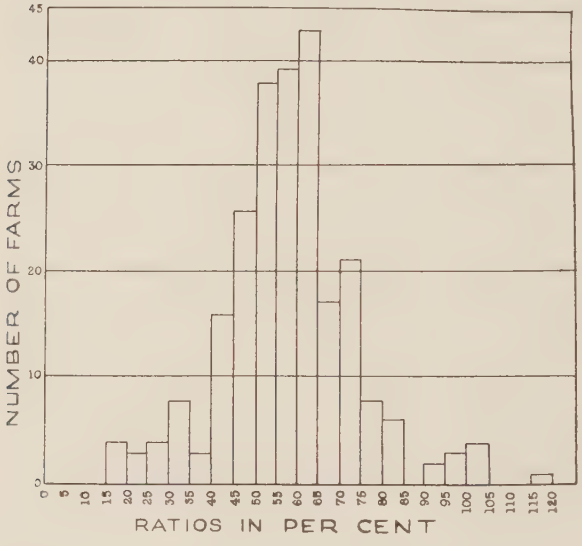
S. C. Hudson[1]

The general property tax, under which the tax on farm property is administered, is essentially a tax on ownership or possession, the total taxes to be raised being allocated on the basis of the value of the property possessed by the individual tax payer. The major responsibility for an equitable distribution of the burden of taxation under this system rests, therefore, with the assessor who evaluates the holdings of the tax payers.

METHOD OF ASSESSMENT

Assessments in Ontario are on the township basis. Each township, incorporated village, town, and city appoints its own assessor, making a total for the province of about 900 assessors, not including deputies. No special qualifications are prescribed for the office of assessor, applications in rural areas usually being received in the form of tenders. Unless otherwise provided by by-law, each assessor is required to begin to make his roll, each year, not later than February 15th and must have it completed, affirmed, and in the hands of the clerk of the municipality by April 30th, at whose office it is to be available for inspection by all persons interested. Appeals against an assessment may be made before a Court of Revision consisting of members of the municipal council, notice of such appeal to be given within fourteen days after the return of the assessment roll.

Figure 1. Histogram of the ratios of assessed to estimated values of 246 Ontario farms



As provided by statute, land must be assessed at its actual value, the value of buildings thereon being ascertained separately as that amount by which the value of the land is increased due to the presence of the buildings; the total assessment being the sum of the assessed value of land plus the assessed value of buildings.

EQUALIZATION

Due to the fact that assessment is made by townships, usually with different assessors for each township, the statutes of the province provide that the real property within each county must be valued at least once in five years by an equalization board consisting of two or more members appointed by the county council. It is also provided that the time for which a valuation shall remain in force may be extended by the county council for a period not exceeding five years. Valuation is made by appraising from 5 to 8% of the different parcels of land in different parts of each municipality and comparing with the valuation of the same properties in the last revised assessment roll of the several municipalities within the county. If the valuation of the county valuators and that of the municipal assessors correspond closely in aggregate, the municipal assessment roll may stand as correct for county.

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purposes. Should there be a material difference between the two, the county valuators are required to make an adjustment by adding or deducting a corresponding percentage to or from the local assessment.

THE ACCURACY OF FARM ASSESSMENT

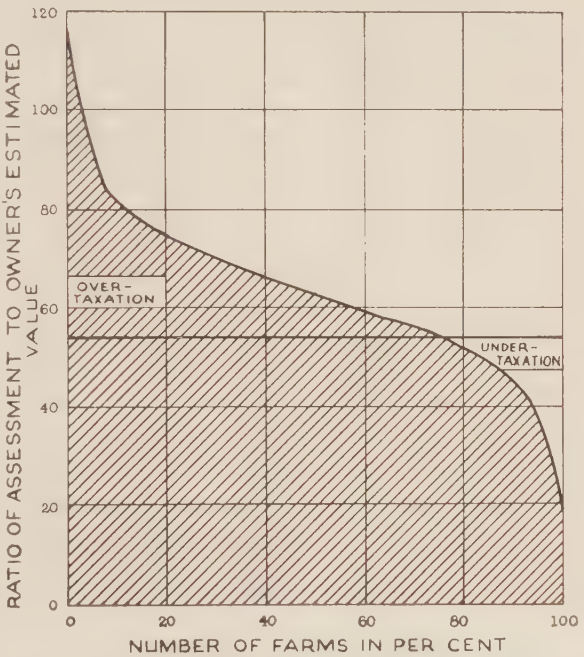
Since an equitable distribution of the burden of farm taxation is dependent, in so far as the individual taxpayer is concerned, on the degree of accuracy by which the various parcels of real estate are assessed, an attempt has been made to study the accuracy of farm assessment in a number of rural municipalities in Ontario.

A number of measures have been evolved for this purpose, the principal one relating to the ratio of assessed to real value of individual parcels of real estate. The greatest difficulty to be encountered in the employment of such a measure is in obtaining a measure of "real value" which is readily acceptable.

Probably the most common measure of real value in studies of assessment is sale value. While there are many points on which the use of sale value in this connection may be recommended, it has certain limitations, chief among which are the effect of forced sales, differences in bargaining power, and ability of the buyer to appraise a farm.

In this study the farm valuation as estimated by the farm operator was taken as the basic measurement of value with which to compare the assessed valuation. While the accuracy of this base depends upon the accuracy of the farmer's estimate and may be open to some criticism, an intelligent farm operator, on account of his intimate contact with his farm and his knowledge of its powers of production, should be in good position to appraise it. The operator's valuation, moreover, in this instance is checked by an experienced farm management investigator. Such an appraisal would be on the basis of productivity which in the final analysis determines the ability to pay. In this connection it must be remembered that irrespective of the fact that property taxes are levied against property and not income, they must ultimately be paid, if at all, from income.

FIGURE 2. DISTRIBUTION OF 246 ONTARIO FARMS ACCORDING TO THE RATE OF ASSESSMENT



The horizontal line represents the average rate of assessment (53.9%). The shaded portion above this line marked "over-taxation" indicates the extent to which certain properties are over-assessed and therefore over-taxed relative to the average of all properties. Similarly the space labeled "under-taxation" shows the extent to which certain properties are under-assessed. Since a larger number of farms are over-assessed than are under-assessed there appears to be a tendency to over-assess low valued farms.

Procedure.—The assessed valuations of some 246 farms in nine townships of Ontario for which farm management records were available were obtained from the

respective township clerks, and the ratio of the assessed valuation to the value as estimated by the farm operator calculated for each farm.

Analysis of Results.—A frequency distribution of these farms by townships according to their ratios of assessed to estimated value is shown in Table 1. A comparison of the average ratios of the several townships indicates considerable variation in the assessment practices of different assessors, the average ratio of assessed to estimated value varying from about 22 to over 70%. It is for the correction of these variations in assessment practices that county equalization is intended.

TABLE 1.—FREQUENCY DISTRIBUTION OF SOME ONTARIO FARMS ON THE BASIS OF THE RATIO OF ASSESSED TO ESTIMATED VALUATION

Class interval (per cent)	Twp. No. 1	Twp. No. 2	Twp. No. 3	Twp. No. 4	Twp. No. 5	Twp. No. 6	Twp. No. 7	Twp. No. 8	Twp. No. 9	Total
15.0 - 19.9	1	—	—	—	—	—	3	—	—	4
20.0 - 24.9	—	1	—	—	—	2	—	—	—	3
25.0 - 29.9	1	—	—	—	—	1	2	—	—	4
30.0 - 34.9	1	1	1	—	—	1	4	—	—	8
35.0 - 39.9	2	—	—	—	—	—	1	—	—	3
40.0 - 44.9	10	2	2	1	—	1	—	—	—	16
45.0 - 49.9	13	8	4	—	—	1	—	—	—	26
50.0 - 54.9	22	6	6	—	—	2	—	2	—	38
55.0 - 59.9	19	12	3	3	—	—	—	1	1	39
60.0 - 64.9	14	14	2	2	5	2	—	1	3	43
65.0 - 69.9	4	8	—	—	—	1	—	2	2	17
70.0 - 74.9	2	7	1	5	1	—	—	2	2	20
75.0 - 79.9	1	1	—	2	3	—	—	2	—	9
80.0 - 84.9	1	3	—	—	1	—	—	—	1	6
85.0 - 89.9	—	—	—	—	—	—	—	—	—	0
90.0 - 94.9	—	1	—	—	—	—	—	—	1	2
95.0 - 99.9	2	—	—	—	1	—	—	—	—	3
100.0 -104.9	2	—	—	1	1	—	—	—	—	4
105.0 -109.9	—	—	—	—	—	—	—	—	—	0
110.0 -114.9	—	—	—	—	—	—	—	—	—	0
115.0 -119.9	—	—	—	—	—	—	1	—	—	1
No. of farms	95	64	19	14	12	11	11	10	10	246
Average ratio	52.7	57.6	50.2	65.7	72.3	43.7	21.9	63.9	68.0	53.9

On studying the distribution of farms within each township according to the assessment ratio great inaccuracy in the assessment of individual farms, as measured on the basis of estimated value, is noted. The totals for all townships show a range in assessment of from about 15 to over 115%. This is shown graphically in Figure 1. However, since items tend to accumulate about the mean, extremes should be compared with the mean rather than with extremes. A more accurate measure of the variation, therefore, is given by the standard deviation[2], a statistical measure which indicates the scattering of items about their mean. Other things being equal, the smaller the standard deviation, the more closely do the various items cluster about the mean. The standard deviation for all farms was 46.25 indicating great inaccuracy in assessment resulting in over-taxation of some farms and under-taxation of others as compared with the average. This is illustrated graphically in Figure 2. The horizontal line represents the average ratio of the assessed to the estimated actual value of the farms studied which was 53.9%. If all farms were assessed at the average percentage of the actual value, the assessment situation would be represented by this horizontal line. The curved line indicates how widely the actual situation varies from this ideal. The fact that the line is more nearly horizontal in the middle

[2] The standard deviation is calculated by finding the difference between each item and the mean, squaring these, totalling, dividing by the number of items, and extracting the square root of the result.

portion of the chart indicates that more of the properties are assessed at the percentage shown in the middle of the vertical scale than are assessed at the extremely low and high percentages. It should be noted that the space marked "under-taxation" below the horizontal line is much smaller in area than that space above the line marked "over-taxation". This indicates that a greater number of farms are over-assessed than are under-assessed, which is explained by the tendency on the part of assessors to over-assess low-valued farms.

The tendency towards over-assessment of low-valued farms is further indicated in Table 2, in which the farms are grouped according to their estimated value by $10,000 intervals for the purpose of determining the relationship between value and assessment. While farms valued under $10,000 were assessed, on the average, at 61.37% of their estimated value, those valued at from $10,000 up to $20,000 had an average ratio of assessed to estimated value of 54.16%, and those valued at $20,000 and over were assessed at 39.39% of their estimated value. Variation of assessment between individual farms within the groups is greater for the first group than for the second as is indicated by the larger standard deviation and coefficient of variation[3] in the first group. The increase in both measures in the last group is attributable to the small sample. Lower valued farms then, are not only over-assessed as compared with those of higher value but in addition to this their assessment is less accurate.

TABLE 2.—RELATION OF VALUE OF FARM TO ACCURACY OF ASSESSMENT

Value of farm (dollars)	No. of farms	Average ratio of assessed to estimated value	Standard deviation	Coefficient of variation
0 – 9,999	113	61.37	40.302	65.834
10,000 – 19,999	114	54.16	28.655	53.015
20,000 and over	19	39.39	32.130	81.573
All farms	246	53.89	46.25	86.16

While it is evident from the foregoing analysis that an individual farm may be assessed anywhere from a fraction of its actual value up to its full value, there is a marked tendency to discriminate against the lower-valued farms by over-assessing them in relation to high-valued farms. It is important, therefore, to study some of

TABLE 3.—RELATION BETWEEN SIZE OF FARM AND ACCURACY OF ASSESSMENT

Size of farm (acres)	No. of farms	Average ratio of assessed to estimated value	Standard deviation	Coefficient of variation
Under 100	87	50.02	31.85	63.67
100 – 200	135	55.92	33.50	59.91
200 and over	24	53.23	32.10	60.29
All farms	246	53.89	46.35	86.01

[3] Whereas the standard deviation measures absolute variation, the coefficient of variation, which is the standard deviation expressed as a percentage of the mean ($c/v = \frac{S.D.}{M} \times 100$), measures the relative variation of different series.

the factors affecting value of property and to determine the extent to which these factors are considered by the assessor.

Size of Farm.—In an attempt to determine the influence of the number of acres in the farm on the assessment, the farms were grouped according to size and the average ratio of assessed to estimated value calculated for each group (Table 3). Since the assessment ratio is essentially the same for all three groups, there is no apparent tendency on the part of the assessor towards giving undue weight to the number of acres in the farm in making an assessment as compared with that of the owner.

Value per Acre.—In order to measure the extent to which assessors are influenced by value per acre, the farms were divided into four groups on this basis, the average ratio of assessed to estimated value being determined for each group. The results, which are presented in Table 4, indicate that farms having a low "per acre" value are over-assessed as compared with those having a high "per acre" value. That is, the assessor apparently does not give sufficient consideration to the "quality" aspect of a farm in making his assessment, with the result that the more productive farm is often assessed at a lower rate than one the productivity of which is relatively low.

Buildings and Improvements.—The average ratios of assessed to estimated value of farms in the groups in which a relatively small proportion of the total value is in buildings are distinctly smaller than in the groups where buildings make up a large proportion of the farm value (Table 5). It would seem then, that in valuing a farm the assessor gives undue weight to buildings with the result that a poor farm which is well equipped in this respect may be assessed much higher than a more productive farm having less pretentious buildings.

TABLE 4.—RELATION BETWEEN THE "PER ACRE" VALUE OF REAL ESTATE AND ACCURACY OF ASSESSMENT

Estimated value of real estate per acre (dollars)	No. of farms	Average ratio of assessed to estimated value	Standard deviation	Coefficient of variation
Under 75	53	67.79	37.70	55.61
75 – 100	83	58.73	22.58	38.45
100 – 125	85	50.86	32.02	62.95
125 and over	27	33.82	20.72	61.28
All farms	246	53.89	46.35	86.01

SUMMARY

The preceding analysis of assessment has indicated that notwithstanding the fact that the law provides that "land shall be assessed at its actual value", the common practice of assessors is to assess property on a percentage basis. In this connection the provision of an equalization board may in itself be considered an admission that assessment is not made on the basis of actual value. It has been demonstrated also that two parcels of farm real estate in the same general locality on which the respective farm operators have placed the same value may be assessed at valuations which differ widely. These differences resulting from inaccuracy of assessment, while significant for all properties, are greater in the lower value groups. A marked tendency to over-assess low-valued properties on the basis of their estimated valuations as compared with high-valued properties is also apparent. This was found to be due, in part at least, to the inability of assessors to give sufficient consideration to the "quality" aspect or "per acre" value of a farm together with the tendency to give undue weight to the value of buildings in assessing a farm.

TABLE 5.—RELATION BETWEEN THE PROPORTION WHICH VALUE OF BUILDINGS IS OF VALUE OF REAL ESTATE AND ACCURACY OF ASSESSMENT

Value of buildings expressed as a percentage of value of real estate	No. of farms	Average ratio of assessed to estimated value	Standard deviation	Coefficient of variation
Under 30	12	34.1	26.68	78.22
30 – 40	29	52.6	19.95	37.93
40 – 50	41	55.5	22.52	40.57
50 – 60	70	53.0	31.70	59.81
60 – 70	54	58.2	23.55	40.46
70 – 80	20	60.1	20.35	33.86
80 and over	20	65.1	21.75	33.41
Totals	246	53.9	46.25	86.16

It should be mentioned that it is not intended that the assessors should be held personally responsible for the inaccurate assessment of farm property but it is felt rather that this is due more to inherent weaknesses of the assessment system which must necessarily be corrected before an adequate appraisal of the present system of property taxation can be made.

A review of the work of the European Commercial Representative of the Fruit Growers' Association of Ontario during the past five seasons, 1929 to 1934 indicates that a very satisfactory development of overseas markets for Ontario fruit has taken place. Andrew Fulton, who is in charge of the London agency for the above organization states in his report that apple exports from Ontario rose from an average of 70,000 barrels for 1920-29 to 375,000 barrels in the 1933 season. Sales have increased from $70,000 in 1929-30 to $1,235,000 in 1933-34. Large savings to shippers have been made in selling charges, amounting to $35 to $70 per car load and totalling $110,000 per annum. This has been accomplished largely through the policy of the Ontario Fruit Growers' Association in assisting growers to standardize their product and by establishing packing houses and cold storage plants. The London representative has done much to develop marketing by pointing out weaknesses in the product and establishing contacts with the trade for standard brands.

Farm economic research in Saskatchewan has been in progress since 1925 under the direction of Dr. Wm. Allen of the University of Saskatchewan. Since 1930, studies of individual farm businesses have provided considerable information on farm indebtedness. From 1930 to 1933 inclusive, records were obtained from 1,323 farms situated in representative districts of Saskatchewan. In 1930, in the northwest park belt, the farming district around Turtleford was studied, and on the heavy land of the west-central portion of the prairie plains, the district of Kindersley was selected. Indebtedness per acre of crop land for these two areas was found to be $11.32 and $10.59 respectively. Similar figures for districts studied in 1931 were as follows: Davidson $10.68, Maple Creek $3.66, and Richmond $3.53. For 1932 the figures were Rosemount, Redford $14.42, Scott $24.29, Wellington $13.92 and Brokenshell $7.07. The 1933 study revealed that indebtedness per crop acre was $19.12 in the Grenfell and Wolseley districts, $17.91 at Balcarres and Indian Head, and $16.36 in the Neudorf and Lemberg districts. The difficulties of the recent years have prevented farmers meeting their obligations and despite reduced costs of operation and curtailed living expenses indebtedness has generally increased.

THE WHEAT SITUATION IN FRANCE

According to an Associated Press report (dated May 25) France has left the ranks of wheat importing countries to join those of exporters. Prior to 1929, France did not produce sufficient wheat to meet her domestic requirements, except in years when exceptionally large crops were harvested. Large crops were grown in 1929, 1932 and again in 1933, so that a surplus of wheat has been built up. Commencing in 1929, several forms of control measures were adopted by the Government in order to protect French farmers.

In pre-war years France produced very large crops. The 1890 crop amounted to 330 million bushels or equivalent to the production of 1932.[1] In the five-year period from 1909 to 1913, production averaged 317 million bushels per annum. From 1928 to 1932, it was 290 million bushels or about 27 million bushels under the pre-war average. France has not reached her pre-war average acreage of wheat which amounted to 16.5 million acres. In 1933 acreage was 13,358,000 and it has not changed materially since 1920.

Domestic requirements of wheat in France average 325 million bushels per annum. Prior to 1929, an amount averaging 50 million bushels had to be imported each year.

Beginning in 1929, France has imposed several regulations to control the domestic wheat market. In May, 1929, the duty on wheat was increased from 37 to 53 cents a bushel and further raised to 85 cents in June, 1930. The general tariff now stands at $1.70 per bushel applicable to countries with which commercial treaties have not been made. It has since been further increased.

A domestic milling quota was established in December, 1929, to provide for the use of 97% of the domestic wheat in French mills. Since then, the extraction ratio has been lowered to 66%. Authorities considered that a low extraction ratio would increase wheat consumption. It is stated that bakers for a time utilized low grade flour which they were not supposed to buy, so that in January, 1934,[2] further regulations were imposed on flour extraction. Millers are now forbidden to sell such flour for home consumption and bakers are forbidden to hold it in store. It is also illegal to buy, sell, offer or utilize flour for bread-making at a price not corresponding to a price to be determined for each province.

A subsidized storage decree, based on a law of April, 1930, was issued in October, 1932.[3] The October decree widened the powers of the original law, providing for the withdrawal of 22 million bushels from the market in 1932, this to be carried into the next season. The principle of the wheat subsidized storage scheme is that producers, by holding part of the current crop, will receive the so-called "conservation or carry-over premium" at the expiration of the storage contract for the wheat held off the market. The government advances 80% of the values of the wheat stored to the farmers and supplies long-term credits at 2% to cover two-thirds of the cost of storage facilities. In 1930-31, about 1.5 million bushels were stored, in 1931-32 about 3.67 million bushels and in 1932-33, it was anticipated that 7 to 18 million bushels would be handled in this way.

In July, 1933, the government inaugurated a price fixing schedule, fixing the price of wheat at $2.05 a bushel (U.S. exchange). This price was advanced to 2.7 cents per month. On the whole it has been a nominal market price. The minimum price was evaded by many millers and those who did adhere to it lost money because they could not compete with the more cheaply produced flour. The provisions mentioned above should prevent the occurrence of this in the future. An amendment to this measure was passed in December, 1933, extending the minimum prices to any surplus resulting from the 1933 crop. This was done to prevent distress

[1] Monthly Review of the Wheat Situation, Dominion Bureau of Statistics, January 24, 1933.
[2] Foreign Crops and Markets, Vol. 28. No. 10.
[3] Foreign Crops and Markets, Vol. 25. No. 21.

sales and to permit farmers to hold their crop until after the end of the season. Another provision of the amendment prohibits the growing of a grain crop after grain in any crop rotation. This will likely limit acreage somewhat.

A sales tax of 3 francs per quintal on all wheat sold has been instituted to help raise revenue for market support. The farmer also pays a commission to the local grain merchant, the total official deduction, including the tax, amounting to about 9 cents per bushel.

In 1933, France attempted to remove 18 million bushels of wheat from the domestic market by granting an export bonus of about $1.43 per bushel. Only 1.8 million bushels were removed as the bounty was found to be insufficient to make French wheat cheap enough for competition on the world market. In December, 1933, the French Government ceased to issue export licences.[4]

ECONOMIC LITERATURE

COATS, R. H., MARSHALL, H., AND GREENWAY, H. F. Wholesale Price Index Numbers of Canadian Farm Products. Internal Trade Branch, Dominion Bureau of Statistics, Ottawa, mimeo. 15 pp.

This monograph provides a record of monthly and annual movements in wholesale prices of Canadian farm products from 1890 to 1933. No such data have been available previously for years prior to 1913, while annual indexes only were available for the years 1913 to 1918 inclusive. The authors include brief notes on the growth of agricultural production, the economic history of the period and the problems of index number construction in addition to the outline of price movements.

Canadian indexes bear out the widely accepted premise that farm products prices react more quickly to broad influences than do those of commodities in general. From the beginning of the war until 1920, the farm products index was steadily above the index of all commodities, and subsequently its decline was more precipitate. From 1929 to 1932, when practically all prices were falling, prices of farm products dropped much more rapidly than the average of all commodities, and this has given rise to an unusually serious dislocation in purchas ng power between the agricultural community and other economic groups.

Field crops exert a dominant influence upon the movement of price indexes of Canada farm products. On numerous occasions field products prices have soared, but these movements as a rule have been of only a few months' duration. The wide fluctuations prevalent in the field product group are attributable chiefly to the occasional precipitous fluctuations of grain and potato prices. Changes of 20% to 30% within one year for these items have been common.

The stability of yearly average price index numbers for animal products shows up in contrast to the wide swings of field product indexes. Such averages had, however, regular and pronounced seasonal movements of considerable magnitude. Milk prices have exerted a considerable influence in the animal products group.

Per capita consumption of beef according to the Agricultural Branch, Dominion Bureau of Statistics, was 65.77 pounds in 1930 and declined in 1931 to 57.92. A further reduction to 56.02 pounds took place in 1932 whereas in 1933 there was a very slight increase to 56.09.

Consumption of pork was 72.92 pounds in 1930 and increased to 85.61 in 1932 during the past year, however, there was a marked reduction to 74.58 pounds.

Consumption of butter has remained almost constant, being reported as 30.59 pounds in 1930; 30.76 in 1931; 30.49 in 1932; and 30.04 in 1933.

The consumption of eggs has declined from 24.92 dozens in 1930 to 21.45 dozens in 1933.

[4] Foreign Crops and Markets, Vol. 28. No. 10.

NOTES

According to the New Zealand Journal of Agriculture, April 20, 1934, the total value of farm production in New Zealand was £52,500,000 in 1932-33, as compared with £50,400,000 in 1931-32 and £83,400,000 in 1928-29. Agricultural production (crops) totalled £8,900,000 in 1932-33, an increase of 11% over the previous crop year. The value of pastoral production was £20,400,000, an increase of 5.7% over the exceptionally low figure recorded in 1931-32. The value of dairy production remained practically the same.

Crop yields, particularly wheat and oats were higher in 1932-33 than in 1931-32. Wool production increased while production and exports of beef, lamb and pork were in excess of the totals for the preceding year. The volume of butter and cheese production increased but the fall in prices counteracted a rise in the total value of these products.

The Crop Reporting Board of the United States Department of Agriculture issues a monthly bulletin on prices received by farmers at local markets. For May 15, 1934 the price per bushel for the following crops was: oats 32.7 cents, barley 42.2, wheat 69.5, rye 51.9, flaxseed 163.7, potatoes 73.7, and apples 113.7 cents. The price received per ton for hay was $8.94 Live stock prices per 100 pounds were as follows: hogs $3.17, beef cattle $4.13, veal calves $4.83, lambs $6.95 and sheep $3.54. Eggs brought 13.3 cents per dozen, butter 21.6 cents per pound and butterfat 21.5 cents per pound. Farmers received $1.45 per hundredweight for whole milk (wholesale), and 9.1 cents per quart for whole milk (retail).

The sixth annual meeting of the Canadian Society of Agricultural Economics was held at Macdonald College, Ste. Anne de Bellevue, June 25–27. The program included the following papers: Some Farm Tax Problems in Ontario; The Preparation of Outlook Material; The Use of Outlook Material in Planning a Farm Program; Farm Management Research; The Peoples' Banks in Quebec; The Census of Agriculture; The Bankground of Present Legislation to Regulate Marketing: The Natural Products Marketing Act; Marketing of Australian Agricultural Products through federal and State Boards; An Appraisal of the Program Initiated under the Agricultural Adjustment Act in the United States; and Possibilities for Export of Canadian Agricultural Products.

Two co-operative wholesale purchasing societies established within the last five years in Manitoba and Saskatchewan have grown into business operators of considerable size. These wholesale companies handle bulk commodities such as gasoline, lubricating oils, binder twine, coal, lumber, fence wire and certain household supplies. The commodities are purchased in car lot quantities and distributed to member societies on a commission basis.

The Manitoba Co-operative Wholesale Limited served 53 local co-operative associations in 1933. Its business during the past year slightly exceeded a quarter of a million dollars. The Saskatchewan Co-operative Wholesale Society Limited was the purchasing agent for 36 local co-operative organizations. Its volume of business in 1933 was just over $300,000. Both companies ended a successful year with a surplus and turned back nearly $3,000 in patronage dividends to their shareholder members.

Continued from page 22—

in that it is excessive or results in undue enhancement of prices or otherwise restrains or injures trade or commerce in the natural or regulated product.

Any person who charges, receives, or attempts to receive any spread which is excessive shall be guilty of an indictable offence and liable to a fine or imprisonment. Consideration of the language used indicates that it is not the intention of Parliament that a committee appointed under the Act shall unnecessarily scrutinize trade and commerce or interfere with recognized margins and reasonable profits. It is the intention, however, to prevent unreasonable spreads and excessive profits. In this respect both producer and consumer are offered a measure of protection.